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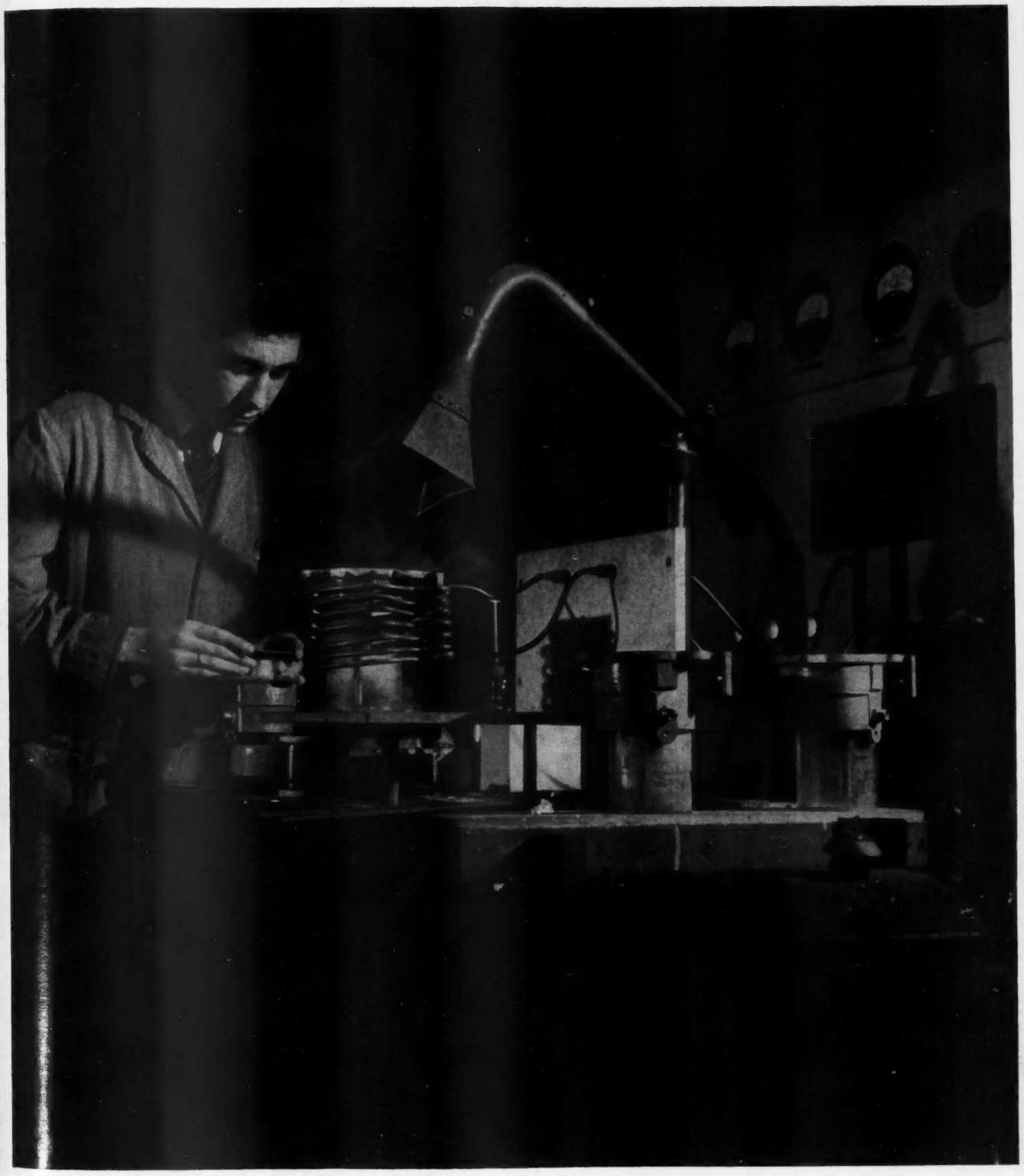

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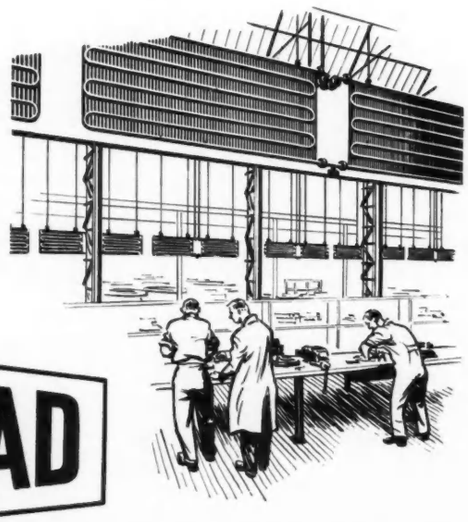

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UNFINISHED PICTURE

A CONVENIENT way to assess last week's debate in the Commons on scientific and technical man-power is to sieve out what is now expected of industrial firms, the Government and education authorities. The main weight of responsibility, the sieving process shows, bears on the Government. Details of the scheme for Diplomas in Technology are still to be worked out, and the Minister of Education, Sir David Eccles, has undertaken to give a full statement before Christmas.

That is his immediate responsibility (and the responsibility, also, of Lord Hives, chairman of the new Council announced in last week's issue). What he gave to the House last week was "really only a sketch and not a finished picture." Nevertheless, he managed to indicate a wide range of urgent tasks for the Government. They had to discover, he said, how, every year, tens of thousands of young men and women could be persuaded to teach or study the subjects demanded for swift technical change in industry, agriculture, the Armed Forces, and so on. The teaching profession must never be allowed to become a depressed profession. There must be more effort made to fire the imagination of school children, their parents, their teachers and their employers with the adventure of the scientific revolution. The time-honoured route to the highest academic qualifications—through the universities—must be supplemented by an alternative and much broader route. (The goal will be the new Diploma, and a feature of the route will be the greater use of sandwich courses, thereby cultivating close partnership between the education authorities and industry.) Uneasiness among the professional institutions as to the wisdom of this scheme is a stumbling block. They would like to see the limited resources of the nation, in money and teachers, concentrated at first on a few colleges, each serving a region. But as this would result in some students travelling away from their local college to a regional college, a "free trade" in students would develop and certain local education authorities would lose their brightest students. The Minister believes that "the best position we can take up is half-way between the view of those who wish to select four or five straight away now, and the view of those local authorities who would like there to be no free trade in students at all."

Government responsibility for higher technological education is also borne by the Treasury, through the University Grants Committee. The Financial Secretary, Mr. Henry Brooke, therefore wound up the debate. Answering criticisms of delays in expanding Imperial College, he said that there were formidable legal difficulties and that it might be necessary to introduce enabling legislation to overcome them.

That would seem to be the sum of the responsibilities that the Government acknowledged. But they were asked to accept more. The debate was opened by Mr. Austen Albu, who gave what the Minister described as "a very thorough survey of this important subject." Mr. Albu's final point was, perhaps, the most trenchant; namely, that a review of the whole problem, and the action which must follow it, should be the responsibility of one senior Minister, not, as at present, divided between the Treasury and the Ministry. On the question of selecting the regional, or advanced colleges, he thought six to a dozen might be a suitable number with which to start. He asked the Minister, too, to recognise that our secondary school system is not good enough for the age in which we live. The number of technical secondary schools is far too low, and thus a great potential source of recruitment to industry is lost. Between leaving school and starting part-time education at a technical college there was generally, Mr. Albu said, a wasteful gap of a year.

Compared with the Government, industry was asked to undertake relatively little. The Minister stressed the value of sandwich courses, which are clearly a major responsibility for engineering firms, and he asked for help in lending part-time teachers. Mr. Frederick Lee hoped that more firms would make offers to equip college laboratories. Mr. Albu saw the need for a faster change in the nature of exports, from the simple and traditional production to the more complicated, and, allied to this change, the need for more post-graduate work. He made special mention of the machine-tool industry and its opportunities in developing advanced machines.

Surprisingly little was said, on either side of the House, of what is expected from teachers and education authorities. Yet clearly they will have to make the new theories work satisfactorily. But before they can start, Sir David Eccles must finish his picture—a picture which, it may be hoped, will not reveal any of the confusion which marred the end of his speech. He said that there was a grave shortage not only of scientific and technical man-power but also of "artists, humanists and men who put spiritual values first." Apart from the fact that there are more artists then jobs for artists, it is unfortunate that the Minister drew this distinction. Scientists, engineers and their colleagues are not noticeably less mindful of spiritual values than artists, or even humanists.

Weekly Survey

Cover Picture. *The technique of soldering by high-frequency induction heating has grown steadily during recent years. Complete items can be built up in one operation, the several parts having been assembled with shaped pieces of solder laid in the joints, and all joints being made at once. The technique can also be conveniently applied to soldering requiring a controlled atmosphere and to mass production lines as it can be made automatic.*

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STEEL IN THE NEWS

Good and bad news came from the steel industry last week. It was good to hear of yet another famous old company being denationalised, and unfortunate—if inevitable—to learn from the Iron and Steel Board of another round of price increases ranging from 9½ per cent. for foundry pig-iron to 5½ per cent. for high-speed and 1½ per cent. for stainless steels. Whether a privately-owned steel industry will be able to contain the growing inflationary pressures on the economy is doubtful, yet it will be interesting to see competition once again, though limited by the nature of their products, between Hadfields, Edgar Allen (whose annual report and accounts published last week announced an increase in trading profit of some £50,000, to £837,401), and other companies in the industry. The Steel Board mention that increased output and efficiency have made possible the absorption by the industry of " some part of the increases in cost." It may well be that restored competition and independent status will bring about further savings: the British engineering industry will need the assistance and support of an efficient steel industry if it is to hold the ground won since the war in overseas markets and now so energetically contested by German, American and other foreign competitors. The Iron and Steel Board's statement—that the new prices " will be approximately 15 per cent. below American and Continental prices " is somewhat theoretical and must remain so in the ignorance of the actual contract prices paid by steel users in Germany, the United States and elsewhere.

The outlook for alloy-steel makers, such as Hadfields and Edgar Allen, is very much that of the engineering industry as a whole, though it may be more affected than that of the average company in the industry by further reductions in armament expenditure. On the other hand, the demand for rolls for sheet and strip mills in the steel and non-ferrous metals industries, for grinding and crushing plant, turbine rotors and blading, permanent-way points and crossings, colliery-vehicle wheels, etc., is very high and seems assured for many years. Announcing the completion of the new research laboratory of Firth Brown Tools, Limited, to the company shareholders in a statement published last week, Lord Aberconway emphasised the importance of research and development and the continued improvement of production equipment to lower production costs and said: " without such cost reductions, price increases to our customers would have to be much more severe in the face of general and continuing rises in wages and in costs of materials, fuel and freight." Only considerable effort in this direction by steelmakers, and other suppliers of materials and services, will enable the engineering industry to keep a major share of world markets.

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GROWING AIR TRAFFIC

Statistics now released of the traffic carried by British airlines in the financial year 1954–55 suggest that under happier conditions they could have been even better and that at one time they looked like being worse. This period saw the grounding of the Comets and the subsequent withdrawal by British Overseas Airways Corporation from the South American routes; but it saw, too, further progress in the replacement of Vikings and Dakotas by Viscounts and Elizabethans on the routes flown by British European Airways.

Total traffic carried by United Kingdom airlines increased by 5 per cent. to 207 million revenue ton-miles, the overall load factor remaining unchanged at 64 per cent. The increase in capacity ton-miles was 6 per cent., a figure which was seriously affected by the troubles of the Comet. The set-back to the Comet was borne by B.O.A.C., and the fall in capacity resulting for the Corporation was almost counteracted by a 10 per cent. increase in the utilisation of aircraft. The fall in capacity and traffic was borne on the western routes. Passengers carried declined by 3 per cent. on the year and passenger-miles flown by 4 per cent. Freight traffic went up by 10 per cent. but this increase was limited to the eastern routes.

B.E.A. increased their capacity by 18 per cent. on the year. This was accompanied by a fall of 8 per cent. in hours flown and 3 per cent. in miles flown, which shows the effect on the figures of the Viscounts and the Elizabethans. The overall load factor increased from 64 to 65 per cent. and total traffic went up by 19 per cent. Passengers carried increased by 13 per cent., passenger-miles flown by 20 per cent., freight by 14 per cent. and mail by 12 per cent.

Independent airlines operating in association with the two Corporations increased capacity by 40 per cent. on the year and total traffic by 39 per cent. There is no doubt that the year 1954–55 was basically a period of growth marred only by circumstances over which B.O.A.C. had no control. The buoyancy of air traffic is further borne out by the encouraging results which the more risky though enterprising projects have had of late. It is known that the British companies interested in carrying freight over the North Atlantic have had an encouraging response so far in what was regarded by many to be a hazardous venture.

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AIRCRAFT CONSTRUCTION IN FRANCE

The annual statement of the Société Nationale de Constructions Aéronautiques du Sud-Ouest contains many interesting facts about aircraft construction in France. The salient points are few, and very much the same as in this country, though in a more acute form. First, the slowing down of rearmament is bringing depression to the industry; second, the cost of research and development and that of special tooling for large-scale production are too great to bear without considerable Government assistance; third, the construction of aircraft is less profitable than most other engineering pursuits—for example, in the case of S.N.C.A.S.O. the manufacture of refrigerators; lastly, French arms budgets are much too small to ensure a volume of orders adequate to keep the industry going. The report therefore points to the need to secure export orders, but states bluntly that " we lack the economic and financial support to achieve this " and goes on to call for Government subsidies such as those granted to the atomic energy industry or to the builders of a transatlantic vessel. There is little doubt that similar problems will emerge forcibly in this country if the rate of the armament programme is further reduced, as is probable, or turns to disarmament, as it well might, during the next two years. How far will Governments be able to go to support companies in research and development programmes and in the maintenance of production equipment in case of eventual need? Probably not nearly far enough to preserve the industry as we know it to-day. The heavy falls in aircraft and armament share prices on the New York stock exchange last week-end are an indication of investors' expectations.

S.N.C.A.S.O. say they have now concluded their development of the bomber Vautour, and that they have registered considerable success with aircraft powered by rocket motors. If large orders for the Vautour are received, the output will be raised mainly by sub-contracting, not—the shareholders are assured—by extensions to the company's existing factories. In fact, despite an order book of £25 million, 66 per cent. higher than the previous year and equivalent to three years' production at the rate of 1954-55, the firm sound a loud and persistent warning concerning the French aircraft industry's future. In advocating close co-operation of aircraft manufacturers in Continental Europe through A.I.C.M.A. (Association Internationale de Constructeurs de Materiel Aéronautique) they are challenging the supremacy of British and American constructors in overseas markets.

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OIL FOR COAL

Last week's debate on the coal situation, which took account of the recent decision of the National Coal Board to raise the price per ton by an average of 11*s.* 5*d.*, received a good deal of advance publicity. In the event, the main outcome was the Government's decision to eliminate coal exports and to revise its views on the rôle of oil as a substitute for coal in the period before nuclear power becomes significant. By 1960, it is hoped that the Central Electricity Authority will be using oil to the equivalent of about 9 million tons of coal a year. The gas industry is also expected to switch its fuel requirements from coal to oil to the extent of about a million tons of coal. The oil industry has said that it can produce oil to the equivalent of a further 15 million tons of coal, making a total substitution of 25 million tons of coal a year. The decision to eliminate the country's international coal trade is bound to have serious effects on shipping; on the other hand the oil-refinery equipment industry will benefit from the increased refining capacity required to meet the growing demand for oil.

The gap between the potential demand and supply of coal has been conventionally considered to be about 20 million tons by 1960, which it had been hoped would be made good by fuel efficiency measures and use of alternative fuels. According to the White Paper on the nuclear power programme issued in February, the demand for coal for electric power is expected to level off in the 1960's as nuclear power takes over. This may in due course set a ceiling to the consumption of coal for power, but there remains the probable increase in demand for fuel from industry in general. At present this growth in industrial production is creating a demand for coal which is increasing at the rate of 3 million tons a year, but coal output expanded last year only by half a million tons. This lag is now to be stopped by further drives towards fuel efficiency, further mine mechanisation (more or less according to programme but with adjustments, no doubt, when management changes recommended in the Fleck report begin to affect planning and production), and concentration on the home market. Beyond this, oil might play a further rôle if necessary. There were, said the Minister on Wednesday of last week, possibilities of using low-flash fuels and even crude oil as a further substitute for coal. This would have certain advantages for the oil-refining industry since it would enable the oil companies to adjust the fractions taken from crude oil to suit the trend away from petrol towards the heavier distillates.

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TWO THOUSAND MILLION FOOD CANS

Sir Robert Barlow, chairman of the Metal Box Company, Limited, announced last week that for the year ended March 31, 1955, sales had increased by £9 million to over £42 million. The company's food-can group of factories, known as the Open Top group, expanded output by 20 per cent. over the previous year and new

factories are being added. The canning of beer has added a new line—so far for export only—as this method of packaging what many in this country like best out of the bottle or barrel, has spread from the United States to most countries of continental Europe. The group's expansion into paper, polythene and other forms of flexible packaging has been continued, and the factory of Brown Bibby and Gregory, Limited (acquired last year) is being extended at a cost of £340,000. Sir Robert points out to his fortunate shareholders the immense potential increase in the demand for containers through the spread of self-service methods in retail selling, which involves the supply of suitable materials for the pre-packaging of fresh produce as well as containers for preserved foods.

The only cloud on M.B.C.'s very bright horizon is the supply of tinplate, but it has been with them for many years now and has not yet seriously checked the group's progress. Sir Robert mentions the improvement brought about by imports from the United States but takes the opportunity of calling for a further strip mill, the need for which "seems clear enough." So say the makers of motor-cars, but the British Iron and Steel Federation sit tight. Can products made of sheet steel and tinplate really lead us out of chronic unbalance in our foreign trade? The answer, and the question of another mill connected with it, are major problems of the next twelve months.

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NEW TUBE MILL IN CANADA

The growth of the oil industry in western Canada has increased the attractiveness of raising the capacity of the Canadian steel-tube industry. Some time ago the German Reinische Röhren Werke established a new plant at Vancouver called Canadian Western Pipeline Mills Limited. This plant was expected to go into production at the end of 1954 and to make seamless as well as welded tubes. The plan to make seamless tubes was dropped, however, and it is now reported that the company is to start production of electrically welded tubes within the next two months. Meanwhile, the Mannesmann group is putting down a new mill in Ontario which it will operate as a subsidiary company with a reported annual capacity of 100,000 tons of steel tube. This development is very similar to the Mannesmann company's expansion into Brazil and Israel, where it was reported some time ago that a new Mannesmann mill was to be installed.

Canadian capacity will be increased by the new project to about 500,000 tons of steel tubing a year, of which about 75 per cent. will be welded and the remainder seamless. It is interesting to note that this Mannesmann project is going forward in an area which has been considered vulnerable to competition from the United States tubing industry and also from Western Europe. There has been the possibility for some time that the inability of manufacturers and others to keep c.i.f. prices on a stable basis in export markets would encourage the growth of local capacity. It looks as though the combination of fluctuating prices and a growing oil industry have touched off this new development in Canada. It remains to be seen if this pattern is repeated in other oil-producing countries which have still no indigenous tube capacity.

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TELEPHONES FOR ALL

According to the Post Office accounts for 1954-55, there were 376,000 applications outstanding for telephone installations compared with 427,000 the year before, and there were 742,000 subscribers with a shared service, compared with 591,000 the year before. By March, 1955, two-party lines had increased to 865,000. It is a sobering thought that if this compulsory form of installation had not been used extensively, the waiting list would by then have reached 800,000. It will be recalled that in October last year the Postmaster-General announced that a big effort would be made to clear the waiting list for telephones. It is clear that some progress has been made but it will take some time before the accumulation of potential subscribers has been worked off.

This pressing problem of catching up with the past tends to obscure the very big opportunity which lies ahead for the telecommunication industry in the home telephone market. An annual report put out for the first time by the Telecommunication Engineering and Manufacturing Association produces some revealing figures about the density of telephones in this country compared with that in some others. It would be expected that the United Kingdom might lag behind the United States in the use of the telephone but the figures show that it lags seriously behind Canada, Sweden, Switzerland and Australia as well. Statistics are reproduced to show that whereas the number of telephones per hundred of the population in 1954 in the United States was 31·27, in Canada 24·01, in Sweden 27·73, in Switzerland 21·90 and in Australia 16·07—the corresponding figure for the United Kingdom was 12·15. Furthermore, the rate of increase per hundred of the population is the second lowest for all 12 countries for which figures are given. In the United States there are more than 50 million telephones in use and they are being added to at a rate of more than 2 million a year. The Association points out that if this country were equipped in the same proportion we should have 16·6 million telephones (compared with the 6·1 million actually installed) and the service would be growing at the rate of 760,000 instead of about 270,000 telephones a year. On the Continent, such countries as Sweden and Switzerland have higher telephone densities and a more rapid rate of growth than we have in this country.

Limitations of supply and not limitations of demand are likely to be the governing factors in the home market for telephones for a long time.

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£100 MILLION OF ORDERS

Two large engineering groups with an international reputation, Simon Carves, Limited, and John Thompson, Limited, recently gave their shareholders cheering news of record turnovers and mounting order books. The turnover of both groups—about £16 million and £17 million, respectively—was sharply up on the previous year and profits were most satisfactory, though both chairmen warned shareholders that keener competition and rising costs must be taken into account in assessing future prospects.

Simon Carves have a relatively small manufacturing capacity and a large number of their 4,689 employees are designers, draughtsmen, contracts engineers and skilled erectors. They sell experience of processes and technical services rather than products, and therefore attach great importance to being leaders in their particular fields, which are, in order of importance: coke ovens and coal-preparation plant, boiler-house plant, chemical plant, mineral treatment plant and constructional engineering. John Thompson, who are primarily manufacturers of boilers and boiler-house plant, also make a wide range of engineering products, such as steel castings and pressings for the motor-vehicle industry, tanks and pressure vessels for the process industries, coal- and ash-handling plant, metal doors and windows, structural steelwork, etc. Both Simon Carves, in partnership with the General Electric Company, and John Thompson, in partnership with Associated Electrical Industries, have set up study groups which are engaged on problems of reactor engineering and heat exchanger design involved in the application of nuclear energy for industrial purposes (Weekly Survey, May 27 and July 1). They should be in a position to supply complete nuclear power stations at home and for overseas in the reasonably near future.

The emphasis placed by the chairmen, Mr. Edward W. Thompson and Lord Simon of Wythenshawe, on the need to improve production methods to stem the tide of rising costs and to keep to the forefront technically, constitutes a timely warning to the engineering industry as a whole.

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UNIFIED SCREW THREADS

It is seven years since representatives of the United States, Britain and Canada agreed to accept the Unified screw thread and thus, in the fulness of time, eliminate the immeasurable waste that has been caused by using different standard threads. There was always the possibility, of course, that formal acceptance would not be followed by voluntary acceptance in industry. In this country the British Standards Institution held a conference in May to assess the progress in adoption, and found that the rate of change-over has been considerably faster than might have been expected four or five years ago. The Unified thread, it was concluded, would ultimately supersede the Whitworth thread.

The conference was held under the chairmanship of Mr. H. A. R. Binney, Director of the B.S.I., and was attended by many representatives of the engineering industries, the Service departments and the nationalised industries. Those from the motor, aircraft, oil and chemical industries and from the Atomic Energy Authority said that they had adopted the Unified thread, and they confirmed that, in general, availability now presented no problem. Further progress in the change-over was particularly dependent on: (1) large organisations, such as the nationalised industries, which place many large orders for equipment and which, by specifying Unified threads, could help to influence and speed the change-over; (2) the stockist, who was responsible for supplying small orders to a great number of small firms; and (3) the many small manufacturers who produce miscellaneous industrial equipment with tapped holes.

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THE MAN WHO STRUCK OIL

Most engineers never venture beyond engineering. There is so much for them to do, and there is so much interest attached to it, that they devote all their time to it. That is perhaps why Mr. Bosworth Monck was able to marshal some impressive evidence, in a paper he gave to the British Association last year, to show that there has been a decline in the status of the engineer in management. An outstanding exception to the rule was Calouste Gulbenkian, "Mr. Five Per Cent.," who died last week at the age of 86.

Mr. Gulbenkian was a student at King's College, London, whence he graduated with distinction from the department of engineering and applied science in 1887. A visit to the Baku oilfields impressed him with the possibilities of the oil industry. He wrote a book and several articles on the theme of a developing petroleum industry, and one of these articles, brought to the notice of the Turkish Minister of Mines, resulted in a request to him to prepare a report on the petroleum resources of the Turkish Empire. That was the "time and tide" in a career which ultimately put him, as *The Times* remarked, among "the select company of men—Rhodes and de Lesseps being also among it—who built up commercial kingdoms of their own which gave them international standing in their own rights."

Gulbenkian—like another great engineer, Lord Nuffield—reached that loftiness of material wealth which can only be matched by a parallel loftiness of spirit, especially in benefaction. Lord Radcliffe, his friend, has said that he always saw England as he had first seen it in the mid-1880's, when he came to study at King's College and lodge at the house of a clergyman in Belgravia—"a shining land of free men and free ways and free learning and free opportunity." That may be an idealised picture of England in the 1880's, as it would be to-day, but it is still an ideal to be defended.

Letters to the Editor

RAILWAY WAGONS FOR BULK MATERIALS

Length not Weight the Limiting Factor

SIR, Mr. J. C. Boustead's letter in your issue of June 17 raises the question of whether the reference, in my article, on "Railway Wagons for Iron Ore and Other Bulk Materials" (March 18, page 347), to the length of a train being the factor limiting its size really does mean "length" rather than "weight" of train. I can assure him that "length" was intended.

The number of wagons which make up a train may be limited by either of two factors. Either the train becomes so long that it cannot be run over the route without great inconvenience (it may, for example, be too long to use any sidings on the route without being split into two portions), or it becomes too heavy for any available locomotive to haul. Which of these two limits is reached first for any particular route and available locomotives depends on the design of the wagon, i.e., its length, tare and carrying capacity. The weight limit, however, can be overcome without much trouble by double heading. This is already a common practice with iron-ore trains on some British routes, and in some parts of the world as many as four locomotives are used to haul heavy mineral trains. The length limitation, on the other hand, is less easily overcome, and for this reason it is regarded as the more important factor on British lines.

Under these conditions the important question is how many tons will each design of wagon allow us to carry in a given length of train, rather than how many tons in a given gross weight of train. The criterion for choosing or designing a wagon is the overall length per ton carried, not the tare per ton carried, and this is the reason for the prominence given to wagon length in my article.

Yours faithfully,
H. R. MILLS.

British Iron and Steel Research Association,
140, Battersea Park-road,
London, S.W.11.
July 14, 1955.

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THICK-WALLED CYLINDERS UNDER INTERNAL PRESSURE

Further Investigation of Results

SIR, I have read with interest the careful experimental work of Crossland and Bones (ENGINEERING, vol. 179, pages 80 and 114) under the heading "The Ultimate Strength of Thick-Walled Cylinders Subjected to Internal Pressure." When considering the very smooth curve of ultimate pressure against K (Fig. 15 in the article), I tried to find the physical explanation of its shape. For small values of K ($K \simeq 1$) the ultimate pressure must be the same as that given by the thin-walled tube formula (Kesselformel or boiler formula):—

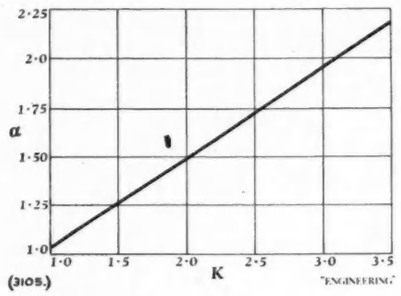
$$p_{max.}\, r_i = \sigma_B\, s, \quad . \quad . \quad (1)$$

(ultimate pressure × inner radius = ultimate strength × thickness of wall),

or expressed in terms of K

$$p_{max.} = (K - 1)\,\sigma_B. \quad . \quad (2)$$

The authors found that for their material $\sigma_B = 32{\cdot}7$ tons per square inch (that is, for the part of the bar at the same radius as the walls of the tubes). For $K = 2$, equation (2) gives $p_{max.} = \sigma_B = 32{\cdot}7$ tons per square inch, which is naturally only a formal value, but a line from this point (in Fig. 15) to the origin should make a tangent to the curve there (Anfangstangente). In fact this is found to be the case, which is a credit to the authors. Having regarded the experimental curve and the straight



line constructed as above, I then put down the relation

$$\alpha = \frac{p_{max.} \text{ from the thin-tube formula}}{\text{experimental ultimate pressure found by the authors}}$$

and found for

K =	1	1·5	2	2·5	3	3·5.
α =	1·0	1·255	1·47	1·705	1·93	2·16.

Plotting these points on a graph I obtained a perfect straight line, which does not pass exactly through the origin but through a point with ordinates (1·0, 1·02). This graph is shown in the accompanying illustration. Expressed mathematically the experimental ultimate pressure is given by the equation:

$$p_{max.} = \frac{\sigma_B}{\frac{1{\cdot}02}{K - 1} + 0{\cdot}456}. \quad . \quad . \quad (3)$$

This is purely an empirical equation which applies only to this one material. I would like to ask the authors if a similar equation with different constants would be obtained for other materials.

Next I would like to comment on Fig. 18 in the article, which shows the axial strain for three cylinders. In these curves the strain increases linearly with pressure up to some yield point. This led me to investigate if these agree with those predicted by the Huber-Mises-Hencky criterion of yielding (Gestaltänderungsenergie hypothesis).

$$\sigma_v = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}}, \quad . \quad . \quad . \quad (4)$$

where σ_1, σ_2 and σ_3 are the principal stresses in the most heavily stressed part of the cylinder, that is at the bore. These stresses are, at the bore

$$\sigma_1 = \text{tangential stress} = \frac{K^2 + 1}{K^2 - 1}\, p, \quad . \quad (5)$$

σ_2 = axial stress (assumed evenly distributed across the section)

$$= \frac{p}{K^2 - 1}, \quad . \quad . \quad (6)$$

σ_3 = radial stress $= -p$.

From Fig. 18 the following values are obtained

K =	1·876	2·662	3·717.
p =	8·2	11·0	14·0 tons per square inch.

These give

σ_1 =	14·8	14·6	16·1 tons per square inch.
σ_2 =	3·3	1·8	1·1 tons per square inch.
σ_3 =	$-p$.		
σ_v =	20·0	22·2	26·0 tons per square inch.

(This could have been reckoned directly by

$$\sigma_v = \frac{K^2}{K^2 - 1}\, p\sqrt{3}. \quad . \quad (7)\,)$$

The three values of σ_v for one and the same material should be equal. That they are not is most likely due to the fact that the strains are measured on the outer surface of the cylinder, and these may not be truly representative of those at the bore. Possibly the stresses and strains at the bore are larger than the simple theory would predict, so that the yield point is reached at a rather lower pressure. To see if this could explain the differences in σ_v I derived the following figures

K =	1·876	2·662	3·717.
p (from Fig. 18) (tons per square inch)	8·2	11·0	14·0.
Correcting factor $\frac{p_i}{p}$ (estimated)	0·93	0·85	0·74.
p_i (estimated internal pressure to give yield at the bore) (tons per square inch)	7·6	9·3	10·4.

From equations (5) and (6)

$\sigma_1 = \frac{K^2 + 1}{K^2 - 1}\, p_i$ (tons per square inch)	13·6	12·35	12·0.
$\sigma_2 = \frac{p_i}{K^2 - 1}$ (tons per square inch)	3·0	1·5	0·8.
Correcting factor (estimated) $\frac{\text{Actual axial stress}}{\sigma_2}$	1·15	1·3	1·5.
Actual axial stress at bore (tons per square inch)	3·5	2·0	1·2.
σ_v (tons per square inch)	18·4	18·7	19·4.

These values of σ_v are not reliable since they rely on two estimated correcting factors, but the results show that the assumption of an axial stress varying across the wall thickness would give a more uniform value of σ_v for various values of K.

This last remark is not intended as a criticism of the authors' work as they were not interested in the yield point but only in the ultimate strength.

Yours faithfully,
HELMUT LEINSS (Dipl. Ing.).

Stuttgart-Vaihingen,
Kirschblütenweg 25A,
Germany.
May 16, 1955.

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TORSIONAL VIBRATION IN MARINE PROPELLERS

Significance of the Propeller

SIR, Mr. J. P. Duncan in his letter, page 69 of your issue of July 15, commenting on my recent article, "Torsional Vibration Damping Coefficients for Marine Propellers (ENGINEERING for May 13, page 594, vol. 179), takes me to task for daring to assert that "In marine propeller-shafting systems, by far the most efficient device for damping torsional vibrations is the propeller itself."

Vibration engineers with marine experience would, of course, appreciate that such a statement was never intended to apply to the case of the higher modes in which the relative amplitude of the propeller is small. It should be fairly obvious that, however intrinsically efficient the damping device may be, if it depends for its dissipative action upon vibratory velocity, then it should clearly be situated at a point of large relative amplitude, as is almost invariably the case with the propeller in the single-noded mode of shafting systems of heavy-oil marine engines.

It can be shown that

$$\frac{\Delta E}{E} = \frac{2\,\Delta E}{J p^2 \theta^2} = \frac{2\pi}{Q}$$

or

$$\Delta E = \frac{\pi}{Q} \times J p^2 \theta^2$$

where J = propeller moment of inertia.
p = phase velocity of vibration.
θ = propeller amplitude.
K = damping coefficient.
ΔE = damping energy per cycle $= \pi K p \theta^2$.
E = maximum kinetic energy per cycle $= \frac{1}{2} J p^2 \theta^2$.

Q = dynamic magnifier* $= \frac{J p}{K}$.

* Yates, H. G., "Prediction and Measurement of Vibration in Marine Geared-Shaft Systems." *Proc.I.Mech.E.*, advance copy dated April 1, 1955.

Hence, for a given moment of inertia, J, and maximum vibratory velocity, $p\theta$, all that I intended to convey was that the cyclical energy dissipation, ΔE, for propellers was far greater, and therefore the dynamic magnification Q far less than, for other sources of damping.

While I would agree with Mr. Duncan on the extreme difficulty of calculating internal damping coefficients precisely, the circumvention he suggests is more apparent than real, since in any case it is still necessary to know the appropriate value of the overall percentage energy dissipation per cycle. However, until such time as more detailed experimental data are available on the relative magnitudes of the various items in the energy-balance sheet, there seems no alternative to such an empirical procedure.

Yours faithfully,

S. ARCHER.

Lloyd's Register of Shipping,
71 Fenchurch-street,
London, E.C.3.
July 20, 1955.

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CONVEYING INFORMATION QUICKLY

Methods for Reaching Different Kinds of Readers

SIR, Owing to illness I have only recently seen Mr. R. T. Carr's letter in your issue of March 18 on the subject of conveying information graphically. In an editorial comment in the same issue, "Words and Pictures," you suggest that my article on "Railway Wagons for Iron Ore and Other Bulk Materials" might have been a suitable subject for treatment graphically in the manner advocated by Mr. Carr. May I therefore be permitted to comment on both Mr. Carr's letter and your own editorial.

As a general principle, I am very largely in sympathy with the view that we should examine carefully our conventional methods of disseminating technical information to see whether we are presenting it in the most suitable way. This is a matter in which the British Iron and Steel Research Association, in common with other organisations which run an information service, is greatly concerned; so much so that the presentation of information has itself become a subject for full-time research by one of the staff of our Information Section. We take the view that a piece of research work has not reached a successful conclusion unless and until it has been applied, and that one of the most important points of our work is to present our findings in such a way as to achieve this result. This means that we have to inform and to influence a variety of people; not only the technical man who is able to understand and appreciate the scientific and engineering details of the work, but also the departmental manager who wants to know what it means in terms of production, and perhaps also the general manager who may need guidance to make a policy decision. It is certain that the same type of approach is not suitable for all these people and we are trying to find out how effective are the different means of communication we employ so that we may be able to suit our written information to the type of reader for whom it is intended.

All these readers, however, and the readers of your own journal, have two things in common: they want to know first of all whether what is set before them will interest them and is worth reading, and, if so, they want to be able to understand it without spending unnecessary time and effort. If an author takes care over the general layout of his article, it is of great help in answering the first of these questions. When an article has an informative title and sub-title, a well-written introductory paragraph, a sufficiency of well-chosen paragraph headings, and conclusions prominently displayed, there is usually little difficulty in deciding whether to spend further time in reading. How can the author still further assist the reader? Has a graphical form of presentation any advantage in this respect? I do not think there is a general answer to this question. Where the information can be presented in the form of simple graphs, most people would prefer to "read" it in this form, as your editorial suggests, but I think the word "simple" is very important in this statement. Complicated graphs can take far longer to appreciate than a written statement.

The article in question was a greatly condensed version of a longer report which was in fact illustrated by a series of graphs. These were purposely omitted from the shorter article on account of their complexity; it was considered that in this particular case the reader would find it easier to assimilate the information in written form.

I think we must be careful not to confuse apparent brevity with ease of appreciation. While I believe that a diagrammatic presentation can be usefully employed more than it is at present, there are cases in which the use of a diagram, although apparently shortening the article, actually takes longer to appreciate than a written explanation.

The method, now becoming common in some American journals, of presenting some of the information in narrative form and the rest in the form of inserted boxes containing diagrams or tabulated matter not referred to in the narrative, I personally find confusing and annoying. Perhaps I am not an average reader in this respect, but I certainly have the feeling that this is an example of the over-use of "diagrammatic" presentation, and I should not like to see it becoming common in our own technical press.

Yours faithfully,

H. R. MILLS.

July 20, 1955.

Editor's note: In a letter published in our issue of April 15 (page 459), Mr. Carr subsequently expanded his ideas, pointing out that words and time could be saved by arranging information positionally, and in the correct relationship, like a genealogical tree. We used the word "graphically" in the title of his first letter not in the special sense of pertaining to graphs but to imply vivid and concise presentation.

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ENGINEERING AND MARINE EXHIBITION

Participants since Inception

SIR, We are asking for information regarding firms who have an uninterrupted connection with the Engineering and Marine Exhibition under its two previous titles starting from 1906.

We have been prompted to do this because we are ourselves receiving an increasing number of inquiries on this subject and unfortunately some of our records were destroyed during the recent war. We feel that it might be of some interest to a number of your readers to recall these associations over such a long period.

Yours faithfully,

KENNETH W. BRIDGES.

F. W. Bridges and Sons, Limited,
Grand Buildings,
Trafalgar-square,
London, W.C.2.
July 14, 1955.

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STEEL CHIMNEY STACKS

Request for Design Data

SIR, I have recently been concerned with the wind excited oscillation of steel chimneys. Although this phenomenon has been discussed in a number of recent articles, there does not appear to have been published any satisfactory method of design against it. I have therefore devised a technique of design which will, I hope, meet this need.

Before placing the method before stack-designers, however, I require more data from actual chimneys than can be gleaned from the literature in order (*a*) to assess the value of the theory and (*b*) to place limits on a design chart. Perhaps some of your readers would be kind enough to supply me with the details that I need.

The structures that I am concerned with are welded, self-supporting steel chimneys (not guyed), which are either lined or unlined. The required details of individual stacks are as follows.

1. Height, diameters, plate thicknesses, thicknesses and density of lining (if any).
2. A statement of whether or not the stack vibrates (as a cantilever) due to wind excitation. (If it does, what is the frequency of the motion and—roughly—at what wind speeds does oscillation take place?)
3. If the stack is not seen to oscillate in wind, its natural frequency as a cantilever (if it is known). (Is this value a calculated one or has it been found by a free-vibration test?)

It should be stressed that details of stacks which do not vibrate are just as important as those of stacks which do.

I should be very grateful for any information that your readers may supply and I wish to assure them that any communication which they make will be treated with the greatest discretion.

Yours faithfully,

R. E. D. BISHOP.

Engineering Laboratory,
University of Cambridge,
Trumpington-street,
Cambridge.
July 21, 1955.

AUTOMATIC CONTROL IN PROCESS INDUSTRIES

London Conference in October

Arrangements are being made by the Institution of Chemical Engineers and the Society of Instrument Technology to hold a joint conference on "Automatic Control in the Process Industries" at Caxton Hall, Victoria-street, London, S.W.1, on Tuesday, October 4, 1955.

There will be morning and afternoon sessions for the presentation of papers, and the subjects dealt with will include fundamentals of automatic process control, dynamics of process plant, automatic process control and chemical engineering, automatic control in the steel industry, automatic control of batch processes, temperature control of large storage tanks, automatic control in the pulp and paper industry, economics of process control, and the development of modern control techniques and the pattern of future progress.

The papers are intended to develop a direct approach to many aspects of automatic control in relation to the design and operation of process plants, mainly for the benefit of persons not possessing a specialised knowledge of the problems involved. Emphasis will be laid on the presentation of data relating to practical installations and applications, but, as far as possible, detailed references to instrument design and construction will be eliminated. The organisers expect that it will be possible to allow considerable periods at each session of the conference for discussion.

A fee will be charged for registration and it is hoped that advance copies of the papers will be available. The address of the secretary of the Society of Instrument Technology is 184 Sherwood Park-road, Mitcham, Surrey, but persons desiring to attend, other than members of that body, should apply to the secretary of the Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1.

PERSONAL

MAJOR C. J. P. BALL, D.S.O., M.C., who has held the post of chairman and managing director, Magnesium Elektron Ltd., since the company's formation in 1934, has relinquished the latter appointment in favour of DR. C. J. SMITHELLS, M.C., but remains chairman of the company. BRIGADIER A. G. COLE, O.B.E., previously assistant managing director, has been appointed commercial director. DR. S. J. FLETCHER remains technical director. Dr. Smithells is succeeded as director of research of the British Aluminium Co. Ltd., by DR. T. G. PEARSON.

MR. C. A. MARTIN, M.I.E.E., consulting engineer to the British Thomson-Houston Co., Ltd., Rugby, has retired after 36 years of service with the company. He is succeeded by MR. G. M. MCILWRICK, B.Sc., A.R.T.C., A.M.I.Mech.E., A.M.I.E.E.

MR. H. DUNLOP and MR. C. E. H. ECKERSLEY, M.I.Mech.E., M.Inst.F., have been elected directors of Davidson & Co. Ltd., Sirocco Engineering Works, Belfast, Northern Ireland.

MR. A. D. BUSBY, B.Sc., A.I.M., who has been a member of the development and research department of the Mond Nickel Co. Ltd., for 18 years, has resigned his position. As from September 1 he is taking up the post of deputy process development manager of the titanium department, I.C.I. (Metals) Ltd., Witton, Birmingham.

MR. D. C. JOHNSON, M.A. (Cantab) has been appointed Professor of Mechanical Engineering at the University of Leeds as from January 1, 1956.

DR. DONALD PARKINSON, F.I.R.I., F.Inst.P., F.G.S., an authority on the reinforcement of rubber with carbon black to resist wear, retires on August 31 from the management of the compounding-research department at the Dunlop Rubber Company's research centre, Birmingham. MR. W. A. CLARKE has been appointed production development manager at the Dunlop German factory, at Hanau, as from August 15.

Following the retirement of MR. H. R. LONDON and MR. W. W. BROWN, the London Division of the Central Electricity Authority have appointed MR. M. G. CROCKETT, M.Inst.F., superintendent at the St. Marylebone generating station, and MR. C. E. SHEPPARD, A.M.I.E.E., superintendent at the Bow generating station. MR. F. R. R. JONES, B.Sc. (Eng.), A.M.I.Mech.E., A.M.I.E.E., has been appointed deputy superintendent at the Deptford West generating station and MR. A. G. COX, Assoc.I.E.E., A.M.Inst.F., at present superintendent at the Blackwall Point generating station, is taking up the appointment of superintendent of the Bankside "A" and "B" generating stations on August 1.

MR. W. R. STOREY, M.B.E., M.I.Mech.E., who was managing director of Imperial Chemical Industries Ltd., Salt Division, until he retired recently, has joined the Graviner Manufacturing Co. Ltd., 1 and 2 Babmaes-street, Jermyn-street, London, S.W.1, as technical adviser, with particular reference to industrial explosion suppression and protection.

Following the death of MR. J. J. CONLAN, the British Electrical and Allied Manufacturers' Association have appointed MR. A. W. BAILEY to be head of the statistical department and MR. R. F. MASTERS to be editor of *The BEAMA Journal*. Mr. Bailey has been a member of the statistical department since 1946, and Mr. Masters has been Mr. Conlan's assistant on the *Journal* since 1950.

MR. P. D. CROWTHER, M.Sc., A.I.M., has been elected a director of Peglers Ltd., Belmont Works, Doncaster.

MR. W. H. R. WEBB, A.C.G.I., M.I.Mech.E., has been appointed by the United Nations Technical Assistance Administration to make a survey of the signalling systems in use on the Iranian Railways with a view to improving the safety and efficiency of their operation.

MR. ERNEST F. THOMPSON, works manager of the Dowlais, South Wales, factory of the Small Heath Group of the B.S.A. Co. Ltd., Birmingham, 11, has been appointed works manager of the Redditch, Worcestershire, factory, including the B.S.A. precision casting foundry.

MR. ARTHUR DAVIES has joined the staff of John I. Thornycroft & Co. Ltd., Woolston, as technical sales representative. He will handle the sales of oil-fuel burning gear for marine and industrial furnaces as well as the sales of engineering and foundry products of the firm's Woolston Works.

MAJOR W. F. F. SCOTT, M.C., director of training and welfare, Tube Investments Ltd., will retire from the board and relinquish his appointments with the company on July 31.

MR. G. E. KNIGHT has been appointed divisional secretary of the Aircraft Division of the Bristol Aeroplane Co. Ltd., Bristol, in succession to MR. E. V. NORCOCK, who has left the company to join the board of Export Packing Services Ltd.

SIR DAVID CAIRNS, Q.C., has been appointed by the Monopolies and Restrictive Practices Commission, 8 Cornwall-terrace, Regents Park, London, N.W.1, to be chairman of two groups which will consider and report on the Commission's reference concerning, respectively, the supply of electronic valves and cathode-ray tubes, and the supply of certain standard metal windows and doors.

MR. W. D. MCKECHNIE has been appointed sales manager (lithopone) of McKechnie Brothers Ltd., 14, Berkeley-street, London, W.1.

MR. CHEUK CHI WONG, of Hong Kong, has been awarded a Bayliss Prize of £15 on the results of the April 1955 (final parts I and II) Institution of Civil Engineers examination.

MR. EDWIN FLETCHER, M.A. (Cantab.), has been appointed deputy director of the European Productivity Agency.

MR. IVOR LLOYD has retired as vice-chairman and managing director and from the board of the Expert Tool and Case Hardening Co. Ltd., of which company he was the founder. His services, however, have been retained in a consultative capacity.

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COMMERCIAL

THE B.S.A. CO. LTD. (SMALL HEATH GROUP), Birmingham, 11, have taken over financial control of the IDOSON MOTOR CYLINDER CO. LTD., Tividale, Staffordshire. No change of policy is envisaged and Mr. T. H. TAFT will continue to serve as managing director.

PLASTER PRODUCTS (GREENHITHE) LTD., Greenhithe, Kent, have opened a London office at 55-56 Windsor House, Victoria-street, S.W.1. (Telephone: ABBey 6500.). It is in the charge of MR. J. T. FREEMAN.

THE HARGREAVES GROUP OF COMPANIES, fuel distributors, have concluded an agreement with the ESSO PETROLEUM CO. LTD. whereby they are appointed distributors of Esso fuel oils over a wide area in the North of England and North Midlands. Operations will be directed from the head office of the Group, at The Calls, Leeds, 2.

W. FEARNEHOUGH LTD., Garden Street Works, Sheffield, 1, opened a new London branch at 2-10 Trundleys-road, S.E.8, on July 25. The new building will also house the London re-grinding service.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING CO. LTD. have formed a new wholly-owned subsidiary company, namely, BRIGHTSIDE HEATING & ENGINEERING CO., LTD., to take over the firm's heating, air-treatment and pipe-work activities. MR. AMBROSE FIRTH has been appointed chairman and MR. T. C. FIRTH, MR. W. S. RICHARDS and MR. W. B. JAMES, directors.

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CONTRACTS

Mobile Cranes. A contract for the supply and delivery of 16 standard non-slewing type mobile cranes for the Eastern Region of British Railways has been placed with RANSOMES AND RAPIER LTD., Waterside Works, Ipswich.

Fuel Oil for Power Generation. A contract between the Central Electricity Authority and SHELL-MEX AND B.P. LTD., Shell-Mex House, Strand, London, W.C.2, has been signed for the supply of fuel oil by the company to a further seven of the Authority's power stations. These are at Ince, Bromborough, Cliff Quay (Ipswich), Carrington (Manchester), South Denes (Great Yarmouth) and Belvedere. The seventh is a projected new station on the Thames Estuary. In addition, the Bankside "B" power station, which is already supplied with fuel oil by the company, is brought under the new agreement. The supply of fuel oil by Shell-Mex and B.P. Ltd. will begin immediately in respect of the Bankside station, but will not reach significant quantities in respect of the other stations until 1958. When the maximum supplies under the contract are being consumed, they will be equivalent to nearly 5 million tons of coal per annum. This is additional to the similar quantity of coal to be saved from the use of fuel oil supplied under the agreement concluded with the Esso PETROLEUM CO., LTD., last month, and particulars of which appeared on page 8 of our issue of July 1, 1955.

Colliery Locomotives. The National Coal Board have placed an order with W. G. BAGNALL LTD., Stafford, for two Diesel-mechanical shunting locomotives for use at the new Lea Hall Pit, near Rugeley in the Cannock Chase area. The locomotives, which will be propelled by NATIONAL M4AA5 Diesel engines developing 220 b.h.p. at 1,500 r.p.m., are of the 0-6-0 type suitable for 4 ft. 8½ in. gauge track. They each weigh 28 tons in working order and are capable of handling trains of 1,000 tons gross weight on the level. Recently, three 16-in. 0-6-0 steam locomotives were delivered by Messrs. Bagnall to the Board, two going to Hem Heath (Stoke-on-Trent) and one to the Rawdon Pit. Nearing completion in the shops are two Diesel-electric 0-6-0 shunting locomotives powered by NATIONAL R4AA6 Diesel engines developing 366 b.h.p. These are for the Board's South-Wales area and are being built to the designs of BRUSH BAGNALL TRACTION LTD., a wholly-owned subsidiary company of the BRUSH GROUP LTD.

Industrial X-Ray Units. The English Steel Corporation Ltd. and the United Steel Companies Ltd. have each awarded contracts to MARCONI INSTRUMENTS LTD., St. Albans, Hertfordshire, for the supply of 250-kV constant-potential X-ray units for their works at Grimesthorpe and Distington, respectively. The equipment for Grimesthorpe comprises a constant-potential high-tension generator, a control unit, an oil cooler and an oil-cooled shock-proof tube head with a special turntable mounting for fitment to a girder suspension system. The Distington equipment is electrically similar but is mounted on a specially-designed two-ton trailer to permit of the easy radiographic inspection of welds and castings irrespective of size. The equipments have a voltage range of from 30 to 250 kV, enabling steel of up to 4 in. in thickness to be penetrated.

Power Station, Transforming Station and Transmission-Line Equipment. Contracts have been placed by the Central Electricity Authority, during June, for power-station, transforming-station and transmission-line equipment amounting, in the aggregate, to £16,647,000. The principal contracts include: for Belvedere power station: the main foundations, underbuilding and associated works, with JOHN MOWLEM & CO. LTD.; and two 7,500-kVA station transformers, with the HACKBRIDGE & HEWITTIC ELECTRIC CO. LTD. For Marchwood power station, near Southampton: two 550,000 lb. per hour boilers, with JOHN THOMPSON WATER TUBE BOILERS LTD. For Portishead "B" power station, near Bristol: ash and dust-handling plant, with JOHN THOMPSON INDUSTRIAL CONSTRUCTION LTD. For Goldington power station, Bedford: steel frame for turbine house and boilerhouse buildings, with JOHN BOOTH & SONS (BOLTON) LTD. For Little Barford "B" power station, near St. Neots: two 60,000-kW turbo-generators, feed-water heating and condensing plants, and one 72-MVA 141·6/11·8-kV generator transformer, with C. A. PARSONS & CO. LTD., also two 550,000-lb. per hour boilers, with FOSTER WHEELER, LTD. For Castle Donington power station, near Derby: one cooling tower, with the MITCHELL CONSTRUCTION CO. For Drakelow "B" power station, Burton-on-Trent: one 120,000-kW reheat turbo-generator, feed-water heating and evaporating plant, condensing plant and auxiliary apparatus, with C. A. PARSONS & CO. LTD. For Staythorpe "B" power station, Newark: two 60,000-kW turbo-generators and feed-heating plant, with the METROPOLITAN-VICKERS ELECTRICAL CO LTD.; one 60,000-kW turbo-generator, with the GENERAL ELECTRIC CO. LTD., and condensing plant for three 60,000-kW turbo-generator sets and feed-heating plant for one set, with WORTHINGTON-SIMPSON LTD. For Willington "A" power station, near Derby: two reinforced-concrete chimneys, with TILEMAN & CO. LTD. For Ocker Hill power station, Tipton, Staffordshire: the main building and superstructure, with SIR ALFRED MCALPINE & SON LTD. For Skelton Grange "B" power station, Leeds: boiler feed pumps, with SULZER BROS. (LONDON) LTD. For West Weybridge substation: 132-kW switchgear, with A. REYROLLE & CO. LTD. For installation between Cardiff West-Pyle and Ebbw Vale: 132-kV overhead lines, with J. L. EVE CONSTRUCTION CO. LTD.

Railway Wagons. The British Transport Commission have placed orders for flat and flat trolley wagons for service on British Railways. R. Y. PICKERING and CO. LTD., Wishaw, Lanarkshire, are to supply one 35-ton flat trolley wagon and eight 45-ton flat wagons. HEAD, WRIGHTSON & CO. LTD., Thornaby-on-Tees, have received a contract for five 40-ton flat trolley wagons. The 35-ton flat trolley wagon, it is interesting to note, is specially fitted for Continental working via the train-ferry services.

MANPOWER RECORDS IN 1954

Most Overtime Since the War

From almost every aspect, last year was a record one in so far as the labour and industrial fields were concerned. More people were at work, wages were substantially higher, and there was a considerable increase in productivity. More overtime was worked in the manufacturing industries than in any other year since the war ended. Indeed, the number of persons so engaged in Great Britain in November last totalled 1,690,000, thereby attaining a record. Short-time working in these industries also reached a very low level, the number of persons varying from 30,000 to 40,000 throughout the year.

Another of last year's achievements, to which the Ministry of Labour and National Service draws attention in its annual report for 1954 (Cmd. 9522, H.M.S.O., price 5*s*.), is that the country's working population reached a level of 23,910,000 in November last; the highest number ever recorded in peace time. The number of men, women and juveniles in civil employment was increased during the year by more than 350,000, to a total of more than 22,700,000, or to approximately 95·4 per cent. of the total working population. During the last two months of the year, the number of persons unemployed was the lowest for that period in any year since the war. The improvement was general throughout the country and was shared by all the main industries.

Unfortunately, another record to be broken in 1954 was that relating to industrial disputes. The number of working days lost owing to this cause was the highest reported since 1945 and amounted to 2,470,000, compared with a total of 2,169,000 for 1953. There were 1,994 disputes, compared with 1,746 in the previous year. Of the total in 1954, no fewer than 1,468 occurred in the coal-mining industry and these resulted in a loss of 470,000 working days, as against 395,000 days lost in the previous year. These large figures were reached in 1954 in spite of the fact that there were no major disputes in the industry in that year. Disputes in the engineering, shipbuilding, and omnibus passenger-carrying industries, and at the London Docks, were the subject of courts of inquiry. In all, 255 disputes were settled following action by the Ministry's conciliation officers, 114 were referred to voluntary arbitration, and a further 185 were decided by the Industrial Disputes Tribunal.

The general level of earnings rose steadily during the year and so did weekly rates of wages and retail prices, and it is worthy of notice that the rise in wages was one half per cent. higher than the rise in prices. Although there was an increase of 350,000 in the number of persons in civil employment and the level of unemployment was so low, the shortage of labour was one of the Ministry's main concerns. In December last, for example, there were 338,000 vacancies which the Ministry's employment exchanges and appointments service were unable to fill, about 68,000 more than in December, 1953.

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ELECTRICITY SUPPLY IN JUNE

During June, 1955, 4,723 million kWh were sold by the Central Electricity Authority to the English and Welsh Area Boards. This was an increase of 11 per cent. over the figure for June, 1954. When corrected for weather conditions and working days, the increase was 9·6 per cent.

The amount of electricity sent out by the Area Boards during the same month was also 4,723 million kWh, of which 109 million kWh were supplied directly by the Central Authority. The increases in the amounts sent out, compared with the corresponding figures in June, 1954, were 11·9 per cent. in the " mainly industrial " and 9·1 per cent. in the " mainly non-industrial " areas.

Obituary

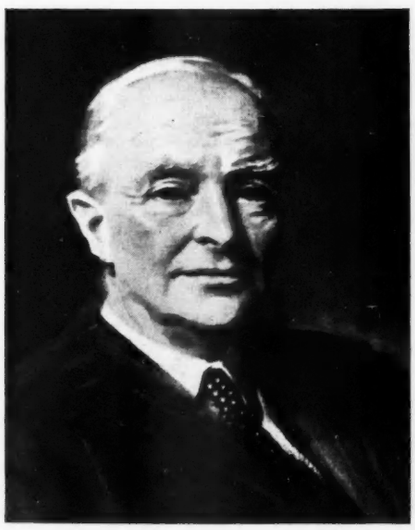
SIR ALLAN GRANT

A Leader of the Steel Industry

It is with great regret that we record the death on July 19, while on a visit to the Island of Skye, of Sir Allan Grant, managing director from 1929 to 1944 of Thos. Firth and John Brown, Limited, and a former President of the British Iron and Steel Federation. He was 79 years of age.

Allan John Grant was a native of Surrey, though of Scottish descent, and was born on September 8, 1875. He was educated at Cheltenham College (in which subsequently he became a member of the Council) from 1888 to 1891 and on May 19, in the latter year he entered the engine works of Laird Brothers, at Birkenhead, as a premium apprentice. There he early distinguished himself by displaying an eagerness to work not always found among premium apprentices and, on completing his " time," was retained on the staff, being sent to Devonport Dockyard, where he spent three years, in charge of the erection on board of the propelling machinery of the battleships Implacable and Montagu. While serving his apprenticeship, he had gained a Whitworth Exhibition, which he utilised in taking engineering at Liverpool University.

In 1904, Grant left the Birkenhead firm (which by then had become Cammell Laird and Company) to become general manager of Chadburn's (Ship) Telegraph Company, Liverpool, with whom he spent the next seven years. While there, he carried through successfully the considerable undertaking of fitting the Cunard liner Lusitania with a new equipment of telegraphs after she had gone into service; and he was also responsible for the first installations of the Bevis-Gibson flashlight torsionmeter for measuring the power output of marine turbines. He relinquished his post in Liverpool in 1911 to go to Sheffield as assistant to the directors of John Brown and Company, where the rest of his professional life was spent. Three years later he was made a local director, and was promoted to a seat on the board of the company in 1919. As stated, he became managing director in 1929, in succession to Sir William Ellis, and when, in the following year, the firm was amalgamated with Thos. Firth and Sons, Limited, to form Thos. Firth and John Brown, Limited, he continued in that office. After his retirement from it in 1944, he remained on the board of John Brown and Company, Limited, Clydebank, until last year. It was while he was still at Sheffield that, on January 6, 1941, he received the honour of knighthood from King George VI in circumstances which were (and, we believe, still are) unique, for His Majesty conferred the accolade in the main shop of the Atlas Works, in the presence of the workpeople.



The late Sir Allan Grant, from a portrait painted by Sir Oswald Birley in 1939.

Sir Allan had served on the boards of a number of other companies associated with Thos. Firth and John Brown, Limited, including, at various periods, the Trent Iron Company, Craven's Railway Carriage and Wagon Company, Davy Brothers, Limited, Nasmyth, Wilson and Company and the Park Gate Iron and Steel Company, Limited. When, in 1934, the new firm of Firth-Vickers Stainless Steels, Limited, was formed, he was appointed chairman, a position which he held for ten years. He took a prominent part in the work of various industrial organisations in addition to the British Iron and Steel Federation, previously mentioned, having been President of the Sheffield Chamber of Commerce, a member of the Board of Trade Advisory Council, President of the Sheffield Branch of the National Union of Manufacturers and, in 1938–39, Master Cutler. In 1932, he led the British Iron and Steel Delegation at the Imperial Economic Conference at Ottawa, and in the same year he served on the committee formed to deal with Sir George May's scheme for the reorganisation of the iron and steel industry. During the recent war, he served as chairman of the Ministry of Production's East and West Ridings Regional Board, of the Admiralty's Armour Technical Committee, and the Armour and Bullet-proof Plate Committee of the Ministry of Supply; and he was a member of the National Production Advisory Council from 1942 to 1945. Among his other industrial activities was membership of the Grand Council of the Federation of British Industries. In local affairs, he was a member of the Court of Sheffield University, and of the Sheffield Church Burgesses Trust, and for 11 years was chairman of the North-East Derbyshire Conservative and Unionist Association. He was also a Justice of the Peace for Sheffield.

With so many calls upon his time, it is not surprising that Sir Allan was seen comparatively seldom at the ordinary meetings of the professional institutions, especially those in London, but he was a member of the Institution of Mechanical Engineers and had served for a number of years on their Council; of the Institution of Naval Architects; and of the Iron and Steel Institute. Always interested in the historical development of engineering, he was a member of the Newcomen Society and of the Cornish Engines Preservation Society. He was also a past President of the Sheffield Society of Engineers and Metallurgists and of the Sheffield and District Section of the Junior Institution of Engineers. For the past 20 years he had been a vice-President of the latter institution, to which he contributed in 1931 a valuable paper on the construction and installation of the variable-density wind tunnel at the National Physical Laboratory—one of the most important and certainly one of the most difficult, feats of heavy engineering production for which he was responsible during his long career.

Tall and of distinguished appearance, keen on sport, a conversationalist of particular charm and widely read in many fields, especially those of a scientific nature, Sir Allan Grant was an outstanding figure in any company, and a welcome one. His friends were legion and were to be found in many walks of life, and it was his pleasure, in Dr. Johnson's phrase, to " keep his friendship in constant repair." Those who had the good fortune to enjoy it will be equally constant to his memory.

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MR. T. E. HARRIS, C.B., C.B.E.

A Director of Ordnance Factories

We regret to record the death of Mr. T. E. Harris, which occurred on Monday, July 18, at the age of 61.

Thomas Emlyn Harris was born at Aberbeeg, Monmouthshire, on May 31, 1894, and was

educated at Abertillery. At the age of fourteen he was apprenticed to Partridge, Jones and Company, colliery proprietors, of Llanhilleth, and in 1912 became a junior assistant in the Abertillery electricity undertaking. Three years later he attended an electrical engineering course at the University College of South Wales, Cardiff, but this was interrupted by war service and it was not until 1921 that he obtained his diploma.

From 1915 to 1917 he was employed under the Ministry of Munitions in making master gauges at Cardiff and Woolwich, but in the latter year joined the Ebbw Vale Steel, Iron and Coal Company as electrical assistant and was engaged in the installation and maintenance of substation and heavy works plant. From 1921 to 1924 he was employed by Metropolitan-Vickers Electrical Company, Limited, at Manchester, on erection and testing, and became a senior assistant for the running of official tests on generating plant. In the latter year he was appointed shop manager at the Royal Ordnance Factories, Woolwich, under Mr. John Severs, where he was in charge of the generation and distribution of electricity and responsible for the maintenance of some 20,000 h.p. of motors.

Subsequently he was shop manager and superintendent of the Royal Ordnance Factory at Blackburn and was then transferred to London as Assistant Director of Ordnance Factories. He was later promoted to be Deputy Director, Director and Deputy Director-General, a position he was occupying at the time of his death.

Mr. Harris was appointed a Commander of the Order of the British Empire in 1946 and was promoted to a Companionship of the Order of the Bath in 1951. He was elected a member of the Institution of Mechanical Engineers in 1937. His connection with the Institution of Electrical Engineers began in 1925 when he became an associated member. He was transferred to the class of member in 1932.

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MR. JOSEPH GARDNER

Gas and Oil Engines

Mr. Joseph Gardner, who died on July 18, was a founder and, until his death, chairman and managing director of L. Gardner and Sons, Limited, Barton Hall Engine works, Patricroft, Manchester. Mr. Gardner, who was 81, was one of six brothers who followed in their father's business, which was originally started in 1868. In 1896, the brothers began the manufacture of gas and hot-air engines at Barton Hall, together with some specialised machine tools, the staff numbering about 80. The works to-day employ about 2,500. Joseph Gardner took particular interest in the foundry, which supplied all the castings for the works; he also developed, in 1928, the type of high-speed compression-ignition engine which still forms the basis of the firm's products.

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MR. GEORGE ELLISON

A Switchgear Pioneer

We also regret to record the death of Mr. George Ellison, which occurred on Sunday, July 17, at Rheinfelden, near Basle, Switzerland, in his 83rd year. He was well known as a pioneer in electrical switchgear manufacture, for which the firm he founded has acquired a high reputation.

George Ellison was educated at Manchester Grammar School and served his apprenticeship with the Oerlikon Company, after which he studied at Winterthur University. In 1893, he went to the United States to take up an appointment as designer and chief draughtsman with the Westinghouse Company. He was also for a time in the employment of the Western Electric Company in Pittsburgh, New York and Chicago.

Returning to Europe in 1898 he joined his father, who had established a machine-tool business in Paris and began to manufacture electrical switchgear in that city. This was so successful that he became known as the father of the French switchgear industry. Eight years later, however, the business was transferred to Birmingham, where it quickly outgrew its original accommodation so that a new factory, from which the present buildings have developed, was established at Perry Barr in 1916. In 1929 Mr. Ellison also founded Tufnol, Limited, for the manufacture of the insulating material of that name; and in 1946 the foundry of Alfred Ellison, Limited, was brought into the Ellison group of companies.

Mr. Ellison was a Life Governor of the University of Birmingham and took a great interest in the industrial welfare work of the city.

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MR. C. A. ABLETT, O.B.E.

It is with regret that we record the death, on July 18, of Mr. Charles Antony Ablett, chairman and managing director of Cooper Roller Bearings Company, Limited, King's Lynn, Norfolk.

Charles Antony Ablett was born on April 30, 1881, and was educated at Westminster and Oundle. He studied at the Central Technical College from 1899 to 1902, and gained his B.Sc. in Engineering with Honours. He obtained his practical training with the General Electric Company, Schenectady, N.Y., U.S.A., where he was largely concerned with experimental work and testing on electric motors. He subsequently worked for the Company at Schenectady, and during part of the time was engaged on erecting plant for the Canadian Niagara Power Company at Niagara Falls. After a year of private study, during which he passed the examinations for the A.M.I.C.E. and gained the Bayliss Prize, he went to the Power and Mining Department of Siemens Brothers' Dynamo Works in London. In 1908 he was put in charge of Siemens steelworks and rolling-mill department, where he was responsible for the electrical installations in 60 rolling mills.

In 1913 he was appointed General Manager of Siemens Company of Canada, where he had the chief technical responsibility for all engineering work, including electric winding installations and complete power-house plants. In 1915 he resigned and joined the Royal Engineers, with whom he served for a time in France. In 1917 he was transferred to the Ministry of Munitions, and was appointed Director of Munitions in Ireland, where he was in charge of five factories. For his services there he was awarded the O.B.E.

In 1924 he and a number of colleagues acquired a controlling interest in Cooper Roller Bearings, and Mr. Ablett was appointed Managing Director. The rise to prosperity of the company was largely due to Mr. Ablett's leadership, and he was particularly interested in promoting its successful American venture. He was elected an associate member of the Institution of Civil Engineers in 1907, and transferred to the class of member in 1919.

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We regret also to record the deaths of:

MR. CHARLES LEAVERS HALL, A.C.G.I., B.Sc. (Eng.)(Lond.), A.M.I.C.E., of Southwick, Sussex, on July 16, at the age of 65. Until his retirement in May of this year, Mr. Hall was a senior executive officer of Balfour, Beatty & Co., Ltd., London, and specialised in hydro-electric work. He was educated at Berkhamsted School and attended the City and Guilds College from 1908 to 1912, obtaining the associateship in electrical, civil and mechanical engineering and the London B.Sc.(Eng.) degree. In his younger days he was on the staff of the irrigation department of the Egyptian Government and joined Messrs. Balfour, Beatty in 1924. He was a keen member of the "Old Centralians."

MR. PERCY MILEY, on July 15. For the past 23 years he had been chief draughtsman of Craven Brothers (Manchester) Ltd., Vauxhall Works, Reddish, Stockport. Much of Mr. Miley's earlier career was spent with this firm, and, among other executive positions held by him, he was for a period of six years the general manager of the machine-tool department of John Hetherington & Sons Ltd., Manchester.

MR. WILLIAM COCHRAN-CARR, of Corbridge, Northumberland, on July 18, at the age of 80. He was chairman and managing director of William Cochran-Carr (1934) Ltd., brick and tile manufacturers, Newcastle-upon-Tyne, and a former colliery owner. On two occasions, Mr. Cochran-Carr was President of the North of England Institute of Mining and Mechanical Engineers, and he was also a member of the Northumberland Coalowners' Association.

SIR JOHN STANLEY STOREY, B.Sc. (Sydney), in Melbourne, Australia, on July 3, at the age of 58. He was a director of a number of engineering and industrial companies in Australia, and a past president of the Australian Institute of Management and the Institution of Production Engineers (Australian Sub-Council). He served as director of the Department of Aircraft Production, Australia, from 1942 to 1946, and a member of the Australian Council of Aeronautics from 1942 to 1947. He was created a knight in 1950.

MR. LAURENCE FRANCIS FOGARTY, at Ruislip, on July 9, at the age of 73. He was educated at the Regent Street and Northampton Polytechnics. After serving as chief assistant to Isenthal, and Company he founded the Zenith Electric Company for the manufacture of small transformers, resistances rectifiers and condensers. He was elected an associate member of the Institution of Electrical Engineers in 1914 and transferred to the class of member in 1926.

MR. HARRY EDWARD YERBURY, M.I.C.E., M.I.Mech.E. M.I.E.E., on July 13 aged 84. Formerly chief engineer of Sheffield Corporation Tramways.

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MODELS AND INVENTIONS

Next Month's London Exhibition

As is usual at the annual exhibitions sponsored by the publishers of *The Model Engineer*, a wide range of machines and equipment will be on show at this year's event, which will be held at the New Horticultural Hall, Greycoat-street, Westminster, London, S.W.1, from Wednesday, August 17, to Saturday, August 27.

Many of the entries will be of the engineering-in-miniature type, displaying, in most cases, a very high level of skill and ingenuity. Internal-combustion engines, power presses, mill equipment, traction engines, motor-car engines and motor cars will be among the exhibits. One of the last mentioned will be a model of the motor car driven by Birkin at Le Mans in 1930. Another model will show a motor car of the future, incorporating an aerodynamic body. There will also be a model of Genevieve, the 1904 Darracq motor car which played a distinguished part in a recent film, as well as a model of a 1955 motor cycle in which the only metal used is milk-bottle tops.

At this year's exhibition, which is the thirtieth of the series, there will be, for the first time, a section devoted to recent inventions. These exhibits have been arranged by the Institute of Patentees, Abbey House, Victoria-street, London, S.W.1, and the great majority of them are the work of members of the Institute. As on previous occasions, there will be a loan section, in which many old favourites, such as a model of M.S. Carnarvon Castle, will be shown. It is expected that there will be many entries for the Students' Cup, which is open for competition by groups of apprentices, the technical classes of schools, and individuals.

The exhibition is organised by Percival Marshall and Company, Limited, 19 to 20 Noel-street, London, W.1, and will be open each day, except Sunday, from 11 a.m. to 9 p.m.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Steam-Engine Builders of Lincolnshire. By RONALD H. CLARK. *Goose and Son, Limited, Norwich.* (12*s.* 6*d.*)

This is the third book describing steam-engine builders of different counties. Many firms that are still well known are mentioned, as well as some that have been forgotten. There are over 140 illustrations. All types of engine have been built in Lincolnshire, the earliest recorded being a marine engine of 1826. This volume also includes addenda, corrigenda and indexes to the two previous books. (Norfolk; and Suffolk, Essex and Cambridgeshire.)

Diesel Engine Principles and Practice. Edited by C. C. POUNDER. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.*2. (84*s.*)

This reference book comprises 26 chapters contributed by eminent specialists in the field of Diesel engineering. It covers the theory, construction and applications of Diesel engines of all types. The editor, Mr. C. C. Pounder, is a director and the Chief Technical Engineer of Harland and Wolff, Limited.

Precision Electrical Measurements. Proceedings of a Symposium held at the National Physical Laboratory in November, 1954. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (27*s.* 6*d.*)

As the title indicates, this publication consists of the 26 papers which were presented at a four-day international symposium in November, 1954, as well as a summary of the discussions. Five sessions were held, each of which was devoted to a particular branch of the subject, that is capacitance and dielectrics, inductance and magnetics, electrotechnics, high-voltage measurement and high-voltage impulse testing techniques. To save time and expense photographic stencils rather than type have been used.

The Principles of Electromagnetism. By E. B. MOULLIN. Third edition. *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (45*s.*)

This book, which was first published in 1932, has been written primarily for students with an engineer's turn of mind and is intended to bridge the gap between mathematical works of a theoretical kind and engineering text books, in which the underlying principles are not fully set out. After a chapter on the elements of magnetism, which covers 62 pages, iron in a magnetic field is dealt with. The equations of electromagnetism and some special problems are then considered in detail, while Maxwell's equations and the electromagnetic field are discussed in a concluding chapter. The treatment is mathematical. Since the initial publication the treatment of dielectric loss has been extended considerably and new information on high frequency resistance of rods and coils has been added. The general theory of round cylinders in uniform fields has been extended with a consequent further treatment of magnetic screening.

The Commissioning of Electrical Plant and Associated Problems. By R. C. H. RICHARDSON. Third edition revised. Monographs on Electrical Engineering, Vol. V. *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (50*s.*)

This is the third edition of a book first published in 1938, since when much development has taken place in the size and scope of electrical plant of all kinds. It has now been revised throughout and a good deal of new information has been added. The subject matter covers the preparation of alternators before they are put into commercial service, their operation in parallel and the various troubles to which they may be liable. Alternating-current motors and transformers are dealt with on similar lines. Shorter sections cover direct-current plant, including rotary converters and rectifiers and finally the steps that should be taken before commissioning circuit-breakers are described. It is hoped that the contents will be useful to those responsible for power plant operation.

Les Moteurs Diesel a Grande Vitesse. Pour l'Automobile, l'Aéronautique, la Marine, la Traction sur Rail et les Applications Industrielles. By P.-M. HELDT. *Dunod*, 92 *Rue Bonaparte, Paris* 6*e.* (2,900 francs.)

This new edition of the publication by M. Heldt takes into account all the refinements brought about on the high-speed Diesel engine during the war and since, both in America and Europe. Very largely rewritten, it treats the chapter on thermodynamics in a more general manner; it includes some new devices relating to injection pumps and regulators; some complementary information on the forces of inertia and the torques which develop in two-stroke engines, as a function of the number of cylinders and the distribution of the crank-shaft bearings; and some information on new French materials of construction, of which the performances, characteristics and details of construction are of importance.

British Petroleum Equipment, 1955-56. *The Council of British Manufacturers of Petroleum Equipment*, 79 *Buckingham Palace-road, London, S.W.*1. (50*s.*)

This volume contains a list of members of the Council of British Manufacturers of Petroleum Equipment and Members' catalogue announcements, covering all petroleum equipment. There is a classified list of equipment and services, with an index to the classified list and an index to members with catalogue entries.

Analysis of Feedback Control Systems: Servomechanisms and Automatic Regulators. By ROBERT A. BRUNS and ROBERT M. SAUNDERS. *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (53*s.* 6*d.*)

This book presents a logical and up-to-date treatment of feedback control components and systems. It aims at giving a complete picture of present-day theory and practice to those new to the field. The book is designed for scientists and practising engineers and senior students in engineering schools.

Elements of Servomechanism Theory. By GEORGE J. THALER. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (53*s.* 6*d.*)

This book describes the elements of feedback control theory and the modern methods of applying them. It is written for the undergraduate student and does not employ higher mathematics. It covers loop and multiloop systems and introduces briefly root locus methods, phase plane techniques, and describing functions.

Four-Cutter Practice. By A. H. HAYCOCK. Principles of Machine Wood-working, Vol. 5. *The Technical Press, Limited*, 1 *Justice-walk, Lawrence-street, London*, S.W.3. (16*s.*)

This book describes machines which can work on all four sides of timber at the same time; it gives methods of setting up and operating the machines, and details of design and how they affect the production of different classes of work. It is for apprentices and others in the wood working industry.

Merchant Ships: World Built. Vessels of 1,000 tons Gross and Over Completed in 1954. *Adlard Coles, Limited*, 7 *Brunswick-place, Southampton.* (25*s.*)

This book contains particulars of new ships built during 1954 in Great Britain and Northern Ireland, and 17 other countries. The vessels are illustrated and briefly described, and in some cases sectional elevations and deck plans are given. It includes a list of shipowners of the world and an alphabetical register of ships completed in 1954; the register is explained in English, French and German.

Patent Law in the Research Laboratory. By J. K. WISE. Reinhold Pilot Book No. 4. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (3 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (24*s.*)

This book is intended to give the industrial research worker an insight into the American patent system. It describes how patent rights are acquired, preserved and lost, and shows when patent counsel should be consulted. It is a book for the research worker interested in obtaining American patent rights.

T.V. Stations: A Guide for Architects, Engineers and Management. By WALTER J. DUSCHINSKY. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (12 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (96*s.*) (Reviewed on page 73, in the issue of July 15.)

Automation. L.P.E. Papers No. 1. *The London Press Exchange, Limited*, 110 *St. Martin's-lane, London, W.C.*2. (Free on application.) (See Leading Article on page 713, in the issue of June 10.)

A History of Technology. Vol. I: From Early Times to Fall of Ancient Empires. Edited by CHARLES SINGER, E. J. HOLMYARD and A. R. HALL, *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (147*s.*) (Reviewed on page 74, in the issue of July 15.)

Automatic Feedback Control System Synthesis. By JOHN G. TRUXAL. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (12·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95, *Farringdon-street, London, E.C.*4. (89*s.* 6*d.*) (Reviewed on page 687, in the issue of June 3.)

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Dewatering Fluids. C. C. WAKEFIELD & CO. LTD., Grosvenor-street, London, W.1. Fluids for the removal of water from surfaces and for giving subsequent protection. Action is mechanical displacement of water film. Various types available for cleansing only or for outdoor protection of up to six months. Suitable for both metallic and non-metallic surfaces, but particularly as a corrosion preventive. Illustrated booklet gives details and uses.

Spherical Valves. DOMINION ENGINEERING CO. LTD., Hydraulic Division, Montreal, Canada. Valves for high-pressure hydraulic systems such as penstocks. Rotating spherical plug with full-bore passage and automatic sealing rings that close at end of movement. Suitable for any method of operation. Sizes up to 83 in. bore and pressures up to 1,750 lb. per square inch. Can also be used for wind-tunnel work. Illustrated leaflet.

Electric Cables. W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., 51-53 Hatton-garden, London, E.C.1. Revised catalogues of electric cables for voltages up to 33 kV and with conductors up to 1 sq. in. cross-section. Catalogue C—paper insulated metal sheathed, gas and oil-filled type; catalogue R—rubber-insulated types; booklet 508—33-kV solid underground types.

Asbestos Insulating Material. THE CAPE ASBESTOS CO., LTD., 114-116 Park-street, London, W.1. "Caposite" Amosite asbestos thermal insulation materials, applicable to pipes with temperatures up to 1,000 deg. F.; thermal conductivity, size and maximum diameters per thickness. Technical data sheets HI.1A and HI.1B.

Commutator Lathe. SMALL ELECTRIC MOTORS, LTD., Beckenham, Kent. Maximum bearing diameter in V blocks $\frac{27}{32}$ in.; maximum shoulder length between V blocks 12 in.; maximum diameter of core stampings $2\frac{1}{4}$ in.; three- or single-phase motor, $\frac{1}{3}$ to $\frac{1}{2}$ h.p. Illustrated leaflet.

Prestressed-Concrete Bridges. B.R.C. ENGINEERING CO. LTD., 53 Grosvenor-street, London, W.1. Description of rigid-frame prestressed-concrete highway bridge: Flannery Bridge over the Kilkerrin Estuary, Co. Galway, Ireland. Illustrated booklet.

Vibration Generators. GOODMANS INDUSTRIES LTD., Axiom Works, Wembley, Middlesex. Vibration generators with moving weights ranging from 6·5 gm. to 9 lb. in six models. Associated power oscillators for the vibrators. Specifications. Illustrated leaflet.

Chlorinated-Rubber Paint. ALLWEATHER PAINTS LTD., 36 Great Queen-street, London, W.C.2. "Pitan" chlorinated-rubber paints, "Galvafroid" zinc-dust primer, and other protective paints. Properties, modes of application and uses. Illustrated brochure.

Expanded Aluminium. EXPANDED METAL CO. LTD., Burwood House, Caxton-street, London, S.W.1. Aluminium mesh made from expanded and flattened metal. Plain or anodised in various colours. Booklet gives details of sizes and examples of applications and colours.

Building Contractors' Equipment. GEORGE PIKE LTD., Alma-street, Birmingham, 6. Concrete breakers, lift trucks, "Tree Hog" for land clearing, lifting jacks, and industrial footwear. Illustrated leaflets.

Torque-Converter Drives. HYSTER CO., 2902 N.E. Clackamas-street, Portland 8, Oregon. Torque-converter drives, "Hystamatic" drives for 3,000-lb. and 4,000-lb. capacity lift trucks. Illustrated leaflet.

Diesel Tractor. MARSHALL, SONS & CO., LTD., Gainsborough, Lincolnshire. Marshall MP6 Diesel tractor, described in ENGINEERING for November 19, 1954 (vol. 178, page 666). Illustrated leaflet. No. 2911.

Metering Transmitters. BAILEY METERS & CONTROLS LTD., Purley-way, Croydon, Surrey. Electronic and moving coil telemetering equipment for flows, pressures and levels. Leaflet No. E231.

Miniature Indicators. BAILEY METERS & CONTROLS LTD., Purley-way, Croydon, Surrey. Miniature equipment for consoles and control desks. Temperature, flow, level, draught, etc. Leaflet E500.

Wall Charts. PETER STUBS LTD., Warrington. Two wall charts, one detailing the efficient use of files and the other listing range of silver steel available. Both about 11 in. by 9 in.

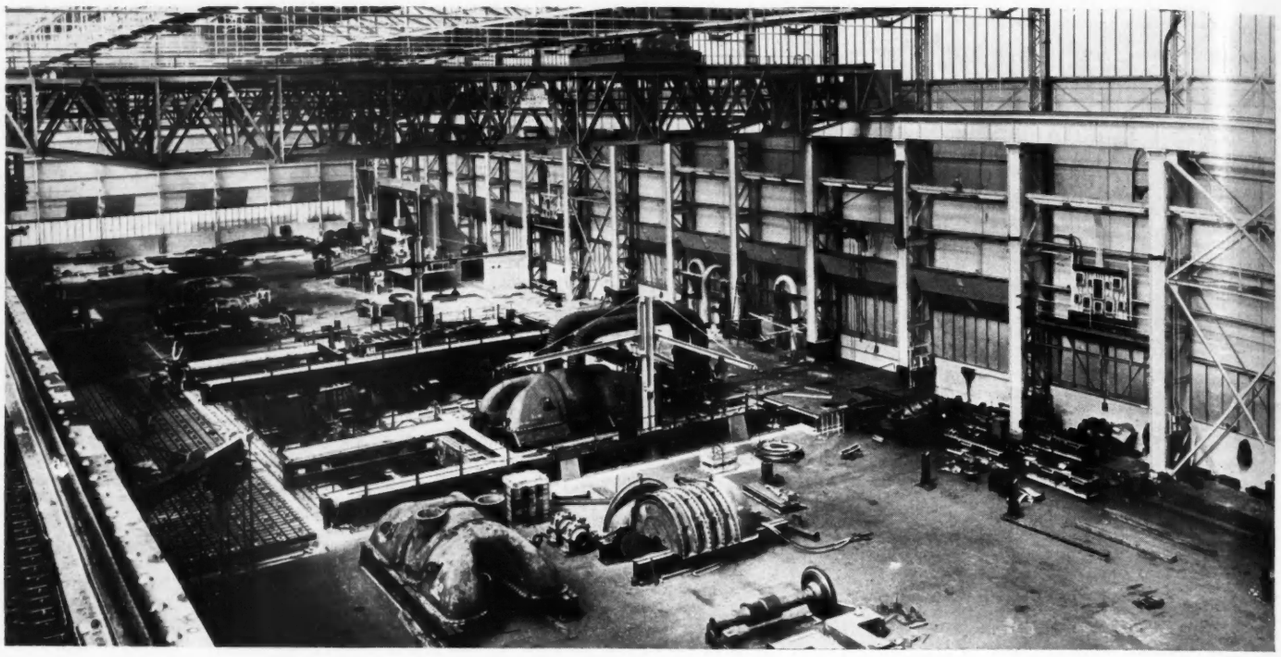


Fig. 1 Interior of the new heavy-turbine shop at the Fraser and Chalmers engineering works of the General Electric Company, Limited, at Erith.

NEW LARGE TURBINE FACTORY

PRODUCTION AND TESTING FACILITIES AT ERITH

A new steam-turbine shop was opened at the Erith factory of the Fraser and Chalmers works of the General Electric Company, Limited, at Erith by Lord Citrine on Friday, July 15. It provides facilities for the erection and testing of units with outputs of up to 400 MW and is complementary to a similar shop for turbo-alternators, which was inaugurated at Witton in 1951.* Sets with capacities of 120 MW are in production and designs for 200-MW units are being completed. It is anticipated that, during the present year, the company will commission some 500 MW of generating plant.

Excavations for the new shop began in 1953, the work including the re-alignment of nearly four miles of railway sidings and the diversion of a number of existing services. The shop itself is a fabricated steel building with brick filling up to 13 ft. from the ground. Above this level the walls and roof are sheeted with metal and are lined with plaster board. It consists of a main bay 364 ft. long by 131 ft. wide and 59 ft. high to the eaves; a view of it is given in Fig. 1, and a machine-tool annexe 284 ft. long and 40 ft. wide, which is illustrated in Fig. 4. It is served by two 60-ton Wharton cranes, which can be operated in tandem, and each of which has a 20-ton auxiliary hoist, with power provided by 500-volt direct-current motors. The contractors for the steel work were Dorman, Long and Company, Limited, Middlesbrough, and W. F. Blay, Limited, Morden Wharf-road, London, S.E.10, for the foundations and building work.

TEST PIT DESIGN

The turbine test pit, which forms the principal feature of the shop, is 81 ft. long and 87 ft. across at the top. It is 13 ft. 1 in. deep and adjoins a second pit 17 ft. deep for the condenser. Both these pits are of reinforced concrete, and the walls of the former are 5 ft. thick in places. In excavating the condenser pit it was necessary to build a pump-house integral with a reinforced-concrete well 20 ft. below ground level in order to drain water from a layer of chalk.

This test pit is of such a size that three machines of the capacities now current or planned can be erected in it simultaneously. The bed itself is designed to allow the greatest latitude both as regards dimensions and positions of the supporting points. For this purpose the base is equipped with plates containing T-slots to receive the 30-in. square cast-iron stools on which the supporting columns stand. These columns are 26 in. square at the top and are 8 ft. 4 in. high. As shown in Fig. 2, they support girders which span the pit through register blocks, the latter being designed to carry packing of variable depths and thus to provide fine adjustment of level. The girders on which the machines are bolted are in three sections, two of which are 17 ft. and the third, at the frame end, 11 ft. long. All the sections are 3 ft. 4 in. deep and 18 in. wide. At each end of the pit there are three 10-cwt. electric hoists. These are mounted on 20-ft. radius swing arms along which they can be traversed manually; the arms being pivoted from a common vertical girder. There are also six 50-cwt. cranes which are mounted on jibs with an 18-ft. radius. A view of the test bed, showing a 60-MW turbine for Ince station in position is given in Fig. 3.

* ENGINEERING, vol. 172, page 620 (1951).

STEAM-RAISING PLANT

Steam for the test bed is supplied from a twin-furnace, oil-fired boiler constructed by International Combustion, Limited, Woburn-place, London, W.C.1, the output of which is 45,000 lb. per hour at a pressure of 665 lb. per square inch. It is differentially fired so that any temperature up to 875 deg. F. can be obtained and is complete with its own forced and induced draught fans, and feed heating equipment, including a de-aerator supplied by the Neckar Water Softening Company, Limited. Provision has also been made for an independently fired boost superheater to be provided at a later stage in order to raise the temperature of the steam to 1,060 deg. F.

CONDENSING ARRANGEMENTS

Each turbine exhausts through a 4-ft. pipe into a 4 ft. 6 in. diameter main trunking of ribbed construction which communicates with the condenser. This condenser was supplied by Worthington-Simpson, Limited, and is capable of dealing with 45,000 lb. of steam per hour at a vacuum of 28 in. Its surface area is 4,000 sq. ft. and it is complete with its own extractor and electrically driven circulating water pumps.

Lubricating oil for the turbines is circulated by motor-driven pumps through oil coolers, storage tanks and oil cleaning and centrifugal plant. All supply arrangements are designed to enable

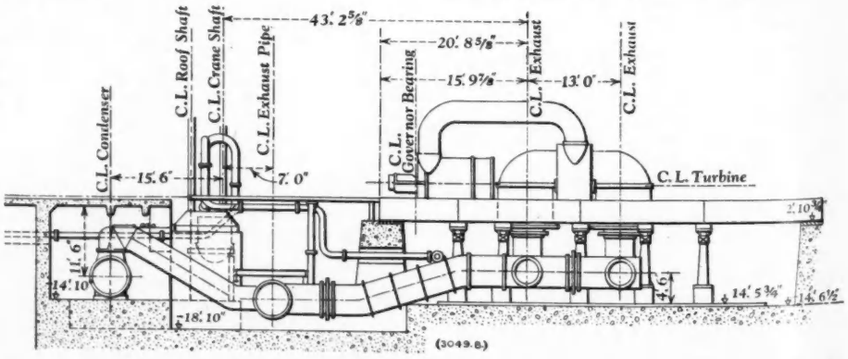


Fig. 2 Diagram of the turbine test and erection pit showing the arrangement of the stools, columns and girders for supporting the machines.

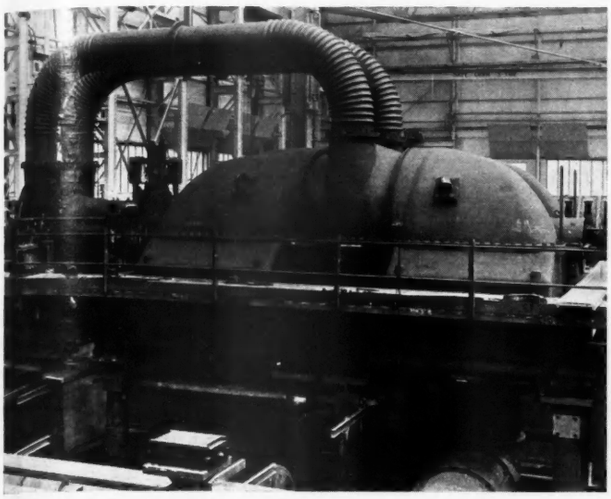


Fig. 3 A 60-MW turbine for the Ince power station of the Central Electricity Authority on test at Erith.

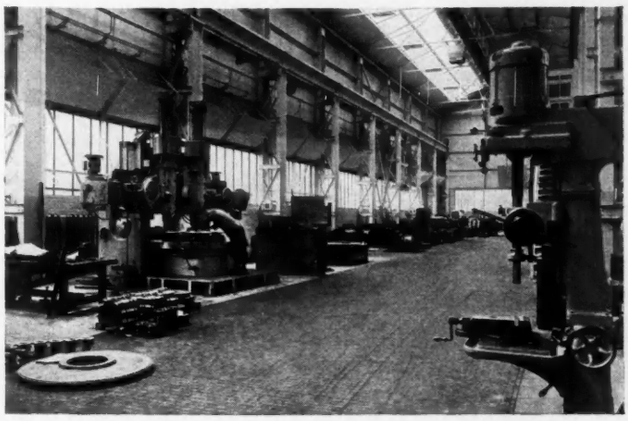


Fig. 4 General view of the machine-tool annexe.

from one to three machines to be run simultaneously or individually at any position on the pit and also for the turbines to be tested after assembly at overspeeds.

The machines on the pit at the opening ceremony in addition to that illustrated in Fig. 3, for the Ince station, included a 60-MW unit for Uskmouth, designed to operate at 900 lb. per square inch and 900 deg. F. and a 30-MW set for Huncoat the steam conditions for which are 600 lb. per square inch and 850 deg. F.

The opening ceremony consisted in starting a 11,215-h.p. turbine, which was on the bed for adjusting the governing valve and auxiliaries prior to being coupled to a 90,000 cub. ft. per minute blower for a closed-circuit air-volume test. This is one of two units which is to be installed in the new works of Colvilles, Limited, Motherwell, and will operate at 400 lb. per square inch and 800 deg. F., with a speed of 2,700 r.p.m.

ELECTRICAL SERVICES

A three-phase supply for the electrical services is brought into the new shop from the 2,850-volt ring-main circuit of the works. It is stepped down to 415 volts in two 250-kVA outdoor transformers, the low-tension sides of which are connected to a six-panel board for distribution. Direct current is obtained at 500 volts and 250 volts through rectifiers. The installation includes a 127-kVA capacitor assembly for power-factor correction.

Lighting in the main shop is obtained from a combination of mercury and fluorescent units. The former consists of three rows of 1-kW lamps, which are supported on brackets from the roof trusses at a height of 58 ft. from the floor. The twin-tube fluorescent fittings are installed on all four walls at a height of 30 ft. and are generally mounted end to end. The average service illumination is 20 lumens per square foot. In the machine-tool annexe the fittings contain one 400-watt mercury and one 750-watt tungsten lamp. As will be gathered from Fig. 1, there is also liberal natural illumination.

The heating installation comprises a boiler from which steam at 200 lb. per square inch is used to heat water. This in turn is pumped through downstream dual-flow heaters with fans for air circulation. In addition, radiant heating panels are mounted at a level of 13 ft. round the shop and there are also pairs of unit heaters above the doors, which are switched on automatically in cold weather.

MACHINE-TOOL EQUIPMENT

The shop is fully equipped to perform the planing, boring and drilling of large castings and the machining of smaller parts. Rotor discs are machined in the shop, but the blades are fitted and the rotors assembled and balanced in one of the other parts of the Erith works. Most of the machine tools are housed in the annexe, although several of the larger units are accommodated in the main shop. These include a Froriep 26-ft. vertical boring and turning mill for work on large parts, such as the exhaust casings, and an Asquith 12 ft. 6 in. radial drilling machine, which has been adapted to take work of over 10 ft. 6 in. under the spindle. The shop is also equipped with a Noble and Lund machine with a 12-in. bar for boring the cylinders.

Machine tools in the annexe, of which a view is given in Fig. 4, comprise internal and external grinding machines, lathes, horizontal and vertical boring, facing and turning machines and a slotting machine.

THE CONCEPTS OF REAL AND VIRTUAL WORK

FUNDAMENTALS OF THE THEORY OF STRUCTURES

*By T. M. Charlton**

It is well known that if the loading of an elastic (linear or non-linear) statically determinate or indeterminate structure is varied, then there is a consequent variation of the (real) work done by the loading and, by the law of conservation of energy, a corresponding variation of the strain energy of the structure. That is,

$$\delta W = \Sigma F\, \delta y = \delta U \quad . \quad . \quad (1)$$

after discarding small quantities of second-order magnitude and where W is the work done by the external forces or loads, F is an external force or load, y is the deflection at F in its line of action due to the loading, δy is an increment of deflection due to load increments δF, and U is the strain energy of the structure. If the structure is rigidly supported and consists entirely of pin-jointed members then

$$\delta U = \Sigma T \delta e \quad . \quad . \quad (2)$$

where T is the force in a member and e is the axial deflection of the member. The summation includes, of course, every member of the structure just as the summation in equation (1) includes every applied load. Substituting for δU from equation (2) in equation (1) gives

$$\Sigma F\, \delta y = \Sigma T\, \delta e. \quad . \quad . \quad (3)$$

Equation (3) is perfectly general: the F's and T's constitute a system of forces in equilibrium and the δy's and δe's constitute a set of displacements which are compatible with the geometry of the loaded structure (which may, or may not, be significantly different from the geometry of the unloaded state†). This equation can be used as a means of setting up the equations of equilibrium of the loaded structure.

Equation (3) is derived above by means of the concept of real work. It can, however, be derived by the totally different concept of virtual work. If any number of forces acting at a point are in equilibrium, such as those shown in Fig. 1, and the point is given a small arbitrary displacement so that the directions of the forces are unchanged, the net work done is clearly zero. That is, $\Sigma F\Delta = 0$, where Δ is the effect of the displacement of the point in the direction or line of action of the force F; the F's constitute an equilibrium system by definition and the Δ's are geometrically compatible. This is a statement of the Principle of Virtual Work; it is concerned with the work associated with a small, arbitrary, *imaginary* displacement, the cause of which is not considered. Owing to the imaginary (or virtual) nature of the displacements, the work quantities are termed " virtual."

Consider now the various joints of a loaded pin-jointed frame as shown in Fig. 2; each one represents the conditions considered above, namely, a point in equilibrium under the influence of a number of forces. If, then, a small arbitrary displacement is *imagined* to occur at each joint such that the geometry of the loaded structure is not changed significantly, the following *virtual* work equations will be obtained:

(*a*) joints at which there are no loads applied:

$$\Sigma T \Delta = 0$$

(*b*) joints at which loads are applied:

$$\Sigma T \Delta - \Sigma F \Delta' = 0$$

since, for equilibrium, the resultant of the T's must be equal and opposite to that of the F's at such joints. (Note that Δ and Δ' merely represent the effects of the arbitrary displacement in the lines of action of the T's and F's, res-

* Of the Department of Engineering, University of Cambridge.

† In practice it is usually a prior requirement that deflections shall be insignificant and structural analysis is usually based upon this assumption. It should be noted, incidentally, that when this assumption is invalid, structures whose members are linearly elastic cease to be linear systems as a whole.

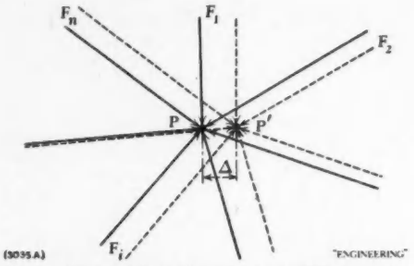


Fig. 1 If a number of forces in equilibrium at a point suffer a small displacement, such that the direction and magnitude of the forces are unchanged, the net work done is zero.

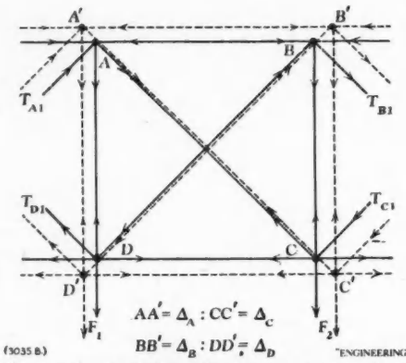


Fig. 2 A set of virtual displacements (magnified) of the type considered in Fig. 1 and co-existing in a pin-jointed frame. The several work quantities associated with such imaginary displacements are termed "virtual" and are, together, zero for a state of equilibrium; had the displacements been due to small changes in the forces, the work quantities would have been real.

pectively.) The equations in sets (*a*) and (*b*) can clearly be added to give the virtual-work equation for the whole structure:

$$\Sigma T \Delta - \Sigma F \Delta' = 0 \quad . \quad (4)$$

where the summations now embrace the whole of the structure and Δ is the total displacement in the line of a member. Equation (4) can, of course, be re-written:

$$\Sigma T \Delta = \Sigma F \Delta'. \quad . \quad . \quad (5)$$

It is, perhaps, necessary, to emphasise here that the displacements Δ and Δ' in the directions of the members and the applied loads, respectively, are entirely imaginary, though sufficiently small that, if they did actually occur, the geometry of the loaded structure would not be altered materially, i.e. they constitute a compatible set of displacements. The structure is being considered merely as a system of points in equilibrium to which the principle of virtual work is applied, regardless of the load-deflection characteristics of the members.

Equation (5) is, however, valid for any set of compatible displacements and though the Δ's and Δ''s are such a set by definitions, another set consists of the real displacements which are caused by a small change (or variation) $\Sigma\ \delta F$ of the loading, i.e., the δe's and δy's of equation (3). Substituting these displacements in equation (5) gives :—

$$\Sigma\ T\ \delta e = \Sigma\ F\ \delta y$$

which is, in fact, equation (3).

The more general of the two work concepts—that of virtual work—is advantageous for the determination of deflections,* as noted by Mohr, since when the geometry of a loaded structure is not materially different from that of the unloaded state (as is usually the case), the total actual displacements, namely, the *e*'s and the *y*'s, due to the loading, form a compatible set so that:—

$$\Sigma\ T e = \Sigma\ F y. \quad . \quad . \quad (6)$$

This equation is of considerable interest: it forms the basis of the method of complementary energy† for ensuring compatibility of strains for statically indeterminate structures with either linear or non-linear elastic members. Castigliano's so-called principle of least work is merely the particular form of the complementary energy method when the members have linear elasticity.

Reference has been made throughout to pin-jointed structures, but the same reasoning can be extended to structures of every kind, irrespective of whether their supports are rigid. Reactive forces can clearly be included in the virtual work equations by considering virtual displacements of the supports: the general form of the virtual work equation (5) is fundamentally the same. Terms including the reactive forces do not appear in the real work equation, however, unless the supports are elastic, or unless a reactive force is considered to be changed by a small amount.

Summarising, it may be said that the work equation consequent upon considering the effect of small changes in forces is strictly concerned with real work (even though it might be argued that the small changes in the forces are virtual changes), whereas the work equation consequent upon considering small, arbitrary, imaginary displacements is concerned with virtual work. It shall be noted that variation of the total potential energy of a statical system is the rigorous classical approach to the Principle of Virtual Work.

* See Appendix.

† Charlton, T. M., "Analysis of Statically Indeterminate Structures by the Complementary Energy Method," ENGINEERING, vol. 174, page 389 (1952). See also: LANGHAAR, H. L., "The Principle of Complementry Energy in Non-Linear Elasticity Theory," *Journal of Franklin Inst.*, vol. 256, page 255 (1953).

APPENDIX

Use of the Principle of Virtual Work for Determining Deflections

The use of the principle of virtual work for determining deflections is best discussed with reference to a particular example. Suppose it is required to find the vertical deflection at point P in the span AB of a rigidly supported continuous lattice girder, shown in Fig. 3, due to loading F_1, F_2 .. etc. (Note that there is no applied load at P, but this is not a requirement of the method.) The girder must first be analysed for the loading ΣF and the deformations *e* of the members within the span AB calculated. A unit load (or, for that matter, any known load) is then considered to be applied vertically at P and the structure ACDGBHJP is analysed as a statically determinate structure, for convenience for the unit load at P (i.e., neglecting, say, members DP and DH). In this way, a system of forces in equilibrium is obtained for the span AB in which the forces in the redundancies are zero by arbitrary choice. Let these internal forces be denoted by T'_{AC}, T'_{AP} .. etc., respectively. Then by the principle of virtual work:

$$1\ y_p = \Sigma\ T' e = T'_{AC}\ e_{AC} + T'_{AP}\ e_{AP} + \ldots$$

or

$$y_p = \Sigma\ T' e$$

because the system of displacements y_p, e_{AC}, e_{AP}, .. etc., due to the applied loading ΣF, is a compatible set (assuming that the loading does not cause a gross distortion) having regard to the geometry of the structure, and the internal forces T′ together with unit load at P constitute a system in equilibrium.

This method of finding deflections is independent of Hooke's law but does depend upon the geometry of the loaded structure being the same (to the first order) as that in the unloaded condition. It can, incidentally, be used for the analysis of statically indeterminate structures in connection with the well-known method of "fitting-in" the redundant members.

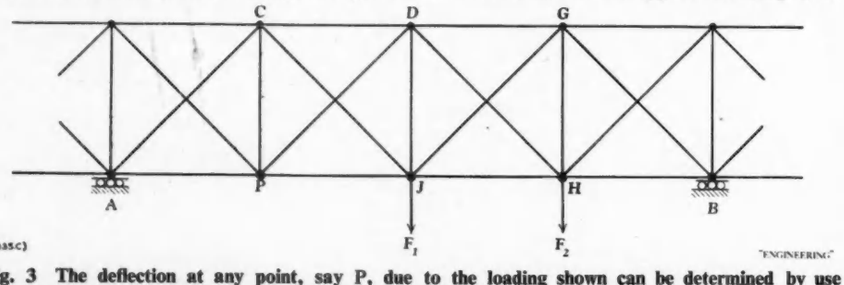


Fig. 3 The deflection at any point, say P, due to the loading shown can be determined by use of the principle of virtual work, so long as the geometry of the structure is essentially unaltered by the loading. The method does not require the members to obey Hooke's law.

★ ★ ★

LAUNCHES AND TRIAL TRIPS

M.S. "KRISTIN BAKKE."—Single-screw cargo vessel, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Knut Knutsen O.A.S., Haugesund, Norway. Main dimensions: 507 ft. overall by 63 ft. 6 in. by 41 ft. 6 in. to shelter deck; deadweight capacity, about 10,300 tons on a draught of 28 ft. 7 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 112 r.p.m. Speed, 17 knots fully loaded. Launch, July 12.

M.S. "GEORGINA V. EVERARD."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for F. T. Everard and Sons, Ltd., London, E.C.3. Main dimensions: 285 ft. by 42 ft. by 19 ft. 3 in.; deadweight capacity, 3,245 tons. Diesel engine developing 1,600 b.h.p. at 250 r.p.m., constructed by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Trial trip, July 14.

M.S. "CONCORDIA FJORD."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Skibs A/S Hilda Knudsen, Haugesund, Norway. Main dimensions: 462 ft. overall by 61 ft. 6 in. by 38 ft. to shelter deck; deadweight capacity, about 8,520 tons on a draught of 25 ft. 11 in. Götaverken eight-cylinder single-acting two-stroke Diesel engine, developing 7,300 b.h.p. at 112 r.p.m. Speed, 17 knots fully loaded. Delivered, July 14.

M.S. "SABANG."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, for the Swedish East Asiatic Co., one of the Broström group of companies, Gothenburg, Sweden. Second vessel of a series of three for these owners. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 29 ft. to main deck; deadweight capacity, with open shelter deck, about 8,400 tons on a draught of 25 ft. 9¼ in., and, with closed shelter deck, about 9,200 tons on a draught of 27 ft. 6 in.; cargo-carrying capacity, 538,700 cub. ft. bale (including 39,000 cub. ft. refrigerated space). Eriksbergs-B. and W. seven-cylinder single-acting two-stroke Diesel engine, developing 8,300 b.h.p. and operating on heavy-fuel oil. Service speed, 17 knots fully loaded. Delivered, July 14.

M.S. "BERGENSFJORD."—Twin-screw passenger and cargo vessel, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Den Norske Amerikalinje A/S, Oslo, Norway. Main dimensions: 518 ft. between perpendiculars by 72 ft. by 38 ft. to "B" deck; cargo-carrying capacity, 1,200 tons; gross tonnage, about 18,500. Two eight-cylinder double-acting two-stroke direct-reversible Diesel engines, developing a total of 18,600 metric b.h.p. at 130 r.p.m., constructed by N.V. Koninklijke Machinefabriek Gebr. Stork & Co., Hengelo, Holland, and installed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Launch, July 18.

RAISING EFFICIENCY OF WORKS RAIL TRANSPORT

COMPARISON OF STEAM AND DIESEL

A conference was held recently by the British Iron and Steel Research Association to discuss "Works Transport." A similar conference was held last year, and an account of it is contained in ENGINEERING for August 27 and September 3, 1954 (vol. 178, pages 273 and 300). The chairman this year was Mr. C. H. T. Williams, managing director of Parkgate Iron and Steel Company, Limited, and chairman of the Operational Research Advisory Committee of B.I.S.R.A. In his introductory remarks the chairman referred to the meeting as being the logical development of last year's conference, which surveyed the problem of works transport generally. The present conference was to consider the more restricted subject of steelworks locomotives, with special reference to the comparative merits of Diesel and steam types.

The first paper was by Mr. M. F. Barnard (British Iron and Steel Federation) on "British Railways under the Transport Act of 1953." It applied to a wider field than works transport, and dealt in particular with the draft maximum charges scheme.

UTILISATION AND AVAILABILITY

In opening the paper on "Locomotive Utilisation and Availability," Mr. M. D. J. Brisby (B.I.S.R.A.) referred to a statement at last year's conference that locomotive operating costs at different works ranged from 27*s.* to 36*s.* per locomotive hour for steam and from 20*s.* to 23*s.* for Diesel engines. These figures were based on total costs for a fleet over a period of one year. Further studies had been made to find the cost of an effective locomotive working hour, which depended on utilisation—the percentage time per shift that the locomotive was usefully employed (that is, running, shunting and weighing) and on availability—the percentage time per year that the locomotive was available for work.

For both Diesel and steam locomotives, the utilisation was about 50 per cent. of shift time, although servicing time for Diesels was about 2 per cent. compared with about 20 per cent. for steamers. Delays accounted for 5 per cent. to 10 per cent. of shift time, and were usually due to operating in congested areas such as melting shops or to derailments. An analysis of the time spent in various activities is shown in Table I

TABLE I.—*Locomotive Occupation (Percentage Shift Time)*

	Steam		Diesel	
	Production	General duties	Production	General duties
Availability				
Utilisation				
Running: Loaded / Light	7·3	13·5	26·7	27·7
Shunting	40·3	33·6	18·5	18·8
Weighing	1·5	3·4	0·4	7·8
	49·1	50·5	45·6	54·3
Delays	5·2	6·0	8·1	10·9
Meals	6·2	6·3	5·6	6·2
Standing	23·8	12·0	38·1	26·5
	35·2	24·3	51·8	43·6
	84·3	74·8	97·4	97·9
Servicing	15·7	25·2	2·6	2·1
	15·7	25·2	2·6	2·1
	100·0	100·0	100·0	100·0

for both Diesel and steam locomotives. The time spent "standing" appeared much greater for Diesels, due to quicker and easier servicing, but could probably be reduced and the utilisation correspondingly increased by the use of V.H.F. radio communication to improve operating efficiency. A planned locomotive service based on an intimate knowledge of production requirements was the best way to increase utilisation. Transport, however, was a service, and priority for certain jobs would sometimes outweigh all other considerations, making it necessary to keep an engine "standing by." Diesels had the advantage that they could be switched off when standing.

The availability of steam and Diesel locomotives was 65 per cent. and 84 per cent., respectively, as shown in Tables II and III.

TABLE II.—*Yearly Locomotive Availability (Steamers), per cent.*

Average age and size of fleet	Works A*	Works B	Works C†	Works D	Averages for four works
	25 years (20 locos.)	32 years (10 locos.)	14 years (47 locos.)	29 years (21 locos.)	
Shed maintenance	5·6	13·8	10·6	15·3	11·3
Shop maintenance	14·1	8·7	8·4	14·0	11·2
Spare	16·6	8·7	15·4	7·9	12·1
Working	63·7	68·8	65·6	62·8	65·4
Total	100	100	100	100	100

* 2 locomotives on days only (working 44-hour week—unrequired 124 hours).

† 8 locomotives on days only (working 44-hour week—unrequired 124 hours).

TABLE III.—*Yearly Locomotive Availability (Diesels), per cent.*

Average age and size of fleet	Works B	Works D	Works E	Averages for three works
	3 years (7 locos.)	4 years (15 locos.)	2 years (4 locos.)	
Shed maintenance	2·4	8·9	10·3	7·2
Shop maintenance	7·2	6·8	8·3	7·4
Spare	—	0·5	3·8	1·4
Working	90·4	83·8	77·6	84·0
Total	100	100	100	100

Both shed and shop maintenance times for steamers were 11 per cent. compared with 7 per cent. for Diesels. These figures depended particularly on the age of the locomotive and on the maintenance policy of the works. Shed maintenance time increased with age, but shop maintenance time mainly depended on the time since the last major overhaul. Spare time apparently increased with age, as the older locomotives were given the lighter duties and working time therefore decreased. Table IV

TABLE IV.—*Yearly Availabilities of Locomotives of Different Age (Steam)*

—	Locos. 1 and 2, 5 years old.	Locos. 3 and 4, 38 years old.	Locos. 5 and 6, 42 years old.
	(Per cent. time)	(Per cent. time)	(Per cent. time)
Shed maintenance	12	13	16
Shop maintenance	10	17	10
Spare	4	7	12
Working	74	63	62
	100	100	100

shows the varying times spent in shed and shop maintenance, spare, and working.

The maintenance policy determined the level of the efficiency of the fleet, the time spent in shed and fitting shop, the frequency of rebuilding and the rate of replacement of the fleet. The total time spent on maintenance of steamers was two to three times greater than on Diesels. The studies made of planned maintenance schemes had shown that the actual time to carry out maintenance corresponded reasonably well with the planned time.

RUNNING AND CAPITAL COSTS

The paper was then concluded by Mr. J. H. Turnbull, also of B.I.S.R.A., who dealt more specifically with costs. Taking 30*s.* per hour as the cost of steamers and 22*s.* 6*d.* for Diesels, the cost of actual effective work was, for 50 per cent. utilisation, 60*s.* per hour for steamers and 45*s.* for Diesels, or less if the utilisation was increased. It could be assumed that a Diesel could be usefully occupied for 70 per cent. and a steamer for 60 per cent. of shift time. Thus, six Diesels could do the work of seven steamers. Diesels, however, had a greater availability, and could be worked for 48 weeks in the year compared with 42 for steamers. Combining utilisation and availability, three Diesels were needed to replace four steamers. Assuming a 400-h.p. Diesel costing £32,000 was equivalent to a 17-in. steamer costing £12,500, the capital outlay would be £66,000 for three Diesels compared with £50,000 for four steamers.

Allowing for depreciation and interest at 12 per cent. for both types, the annual charge would be £8,000 for Diesels and £6,000 for steamers, equal to £165 for Diesels and £143 for steamers per working week. Maintenance costs were about 5*s.* for Diesels and 7*s.* 6*d.* for steamers per working hour, that is, £1,800 for Diesels and £2,100 for steamers per annum. On the "3 for 4" basis, this represented £5,400 for Diesels and £8,400 for steamers per annum, a saving of £3,000.

On running costs for 168 hours per week, a saving of £441 would be made with Diesels, assuming 22*s.* 6*d.* and 30*s.* as hourly running costs for steam and Diesel. Over a full year—48 weeks for Diesels and 42 for steamers—this saving became £15,000, which almost covered the difference in initial outlay, showing that a Diesel fleet is a more economic proposition than a steam fleet.

In the discussion that followed several speakers stressed the point that the relative use of existing Diesel fleets tended to obscure costings because any comparison with, say, thirty-year old steamers involved very different levels of maintenance costs. The ideal basis would, of course, be a comparison between new Diesels and new steamers. It was also pointed out that there is little evidence yet available on the cost of a major rebuild of a Diesel locomotive. In this connection, Mr. Turnbull said that while the general level of replacement costs was steadily increasing, the expanding volume of Diesel manufacture tended to counteract the rising trend. Another speaker suggested that maintenance figures were likely to be affected by the type of transmission employed, a point which would no doubt emerge as detailed figures became available following increased experience and usage.

On the question of utilisation, it was suggested that the tendency for older steamers to be kept

Fig. 1 Erosion of a cylinder liner, caused possibly by impingement attack and electrolytic action. Normal water treatment had not proved effective in dealing with this, and silicon-coated liners were being tried.

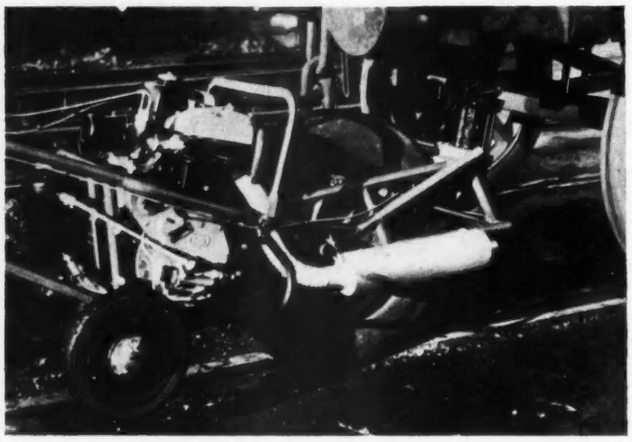


Fig. 2 A shunting device driven by a petrol engine. The pneumatic tyre has a tread for running on rails, and the shunter can move approximately eight loaded British wagons.

on "spare" might make comparison unjustifiable. It was further pointed out that utilisation was directly connected with works layout; a good layout supported by efficient communications would almost certainly be reflected in satisfactory utilisation figures.

General agreement was expressed that operators were not taking full advantage of the greater availability of Diesels, possibly due to the gradual change-over from steam to Diesel. Eventually this greater availability might well lead to a reduction in the number of locomotives employed, and it was clear from the discussion that the point was being closely studied in many works.

LOCOMOTIVE CONTROL BY V.H.F. RADIO

Mr. H. E. Bottle (Pye Telecommunications, Limited) then delivered his paper on "Radio Communication on Locomotives."

He recalled that V.H.F. radio was developed during the war for the control of vehicles, small craft, aircraft, etc., where reception over a limited range only was required for security purposes. Since the war, development had continued and large numbers of road-vehicle transport systems were now equipped; few locomotive fleets had so far been equipped, however, although a system had been satisfactorily installed at the I.C.I. works at Billingham. Extra protection was required to exclude damp and heat, particularly in the case of steamers, and to prevent damage by rough usage.

A strong metal case with rubber sealing to make it waterproof and almost airtight had been designed specially for siting externally on steam locomotives. The radio equipment, resiliently mounted inside, had a power output of 5 watts; it was operated from an R.F. 12-volt battery and used a small aerial. The load on the battery when transmitting was 7 amperes and when receiving, 4·5 amperes. The load when receiving was the main consideration where the battery life was concerned, as the set was switched to receiving most of the time. A similar unit had been developed for use in locomotives with no battery power supply, using a small turbine generator giving an output of 24 volts, 500 c/s alternating current, which would take a load of 350 watts. The additional power could be used for electric lighting on the locomotive. In Diesels employing 12-volt batteries the radio equipment was charged by the Diesel starter battery, or, if this was 24 volts, through a series resistor; but if the starter battery was 80 volts an extra rotary generator taking 80 volts on the input side and giving a 12 volts output was usually provided.

A small robust lightweight set with an R.F. power output of 2 watts and an audio output of 1·6 watts, powered by a 12-volt battery supply, had been designed for use on tractors, fork-lift trucks, etc., and would probably be quite adequate for use in works locomotive systems. A special case was being designed for protection, but the set could be mounted in the heavy cast metal container already mentioned.

The hand micro-telephone for use inside locomotive cabs was designed so that spray and damp would not penetrate into the magnet assembly. The control box was also of robust cast metal construction to protect the hand micro-telephone when not in use. Even with the high noise level in locomotive cabs, good reception at all times was ensured, where a loudspeaker system would be unsatisfactory. The earpiece was alive whenever the set was switched on, as indicated by a small light on the control box.

Some trouble with transformers heating up and valves failing had been experienced with Diesels when the supply frequency fell below 500 c/s. Tests with controlled frequency and steam pressure, however, had shown that the valves and transformers had a life well above normal.

New types of locomotives, such as the Sentinel type with automatic oil-fired boilers, designed to maintain constant pressure, would require a battery and charger for automatic firing of the boiler. It was therefore proposed to install V.H.F. radio equipment using a 12-volt battery supply.

In the discussion on this paper, the usefulness of V.H.F. radio was emphasised by several speakers, the major criticism being directed towards the weight of present equipment; it was stressed that 8½ lb. is a noticeable burden after a few hours. Mr. Bottle mentioned that experiments were being carried out with a new model employing transistors instead of conventional valves, a development which should result in lighter and more compact apparatus.

There was some clash of opinion on the best way of employing radio communication in steelworks. One speaker stated that at his works where there was a fleet of 70 locomotives and a correspondingly heavy volume of traffic, they had found that the most suitable system was to decentralise control. The walkie-talkie principle would appear to be very suitable under such circumstances. This view was challenged by another speaker who put up a strong case for a permanent transmission point which would make possible a much more positive control.

OPERATING DIFFICULTIES: RE-RAILING AND CAB HEATING

The next paper was given by Mr. G. K. Tatterson of John Summers and Sons, Limited, on "Methods of Overcoming Specific Difficulties with Locomotive Working."

Dealing with methods of re-railing locomotives, where speedy restoration of the service without further damage to the locomotive or vehicle derailed was essential, he agreed that works with 25-ton or 50-ton rail cranes had few difficulties. A number of works, however, were not equipped with such heavy plant. The "Hydralite" jacks of 25 and 50 tons capacity with 12-in. and 6-in. lift, respectively, had been found most useful at his works. The re-railing equipment, including lifting and packing blocks of various widths, was kept ready in a special trailer and hauled to the scene of the mishap by Land Rovers. A traverser was used for slewing the locomotive over on to the rails when it had been lifted so that the flanges were clear of the rails.

Pointing out that improved working conditions for drivers were not the least of the advantages of Diesel locomotives, Mr. Tatterson said that nevertheless in cold weather, particularly in exposed places, cabs became extremely cold. The heating units supplied by the makers usually depended on the heat of the engine and these were sometimes insufficient unless the engines were running continuously. This, of course, was wasteful, particularly in the 500-h.p. class, where heavy coking occurred in the cylinder heads.

At Shotton small solid-fuel heating stoves had been installed. These were totally enclosed and mounted on a bed-plate, so that any fire risk could be regarded as negligible. Although quite small, they had proved perfectly adequate and had eliminated the power wastage and engine deterioration resulting from running the engines specifically to operate the built-in heaters.

With regard to the number of men required for shunting, Mr. Tatterson stated that some duties, such as moving ingot cars or slag pots, could be efficiently carried out by one shunter per locomotive. For duties such as sorting

Fig. 3 The "Wagontroler" is remotely controlled and runs on a special bogie track. Trains up to 170 tons in weight can be moved on gradients of 1 in 70.

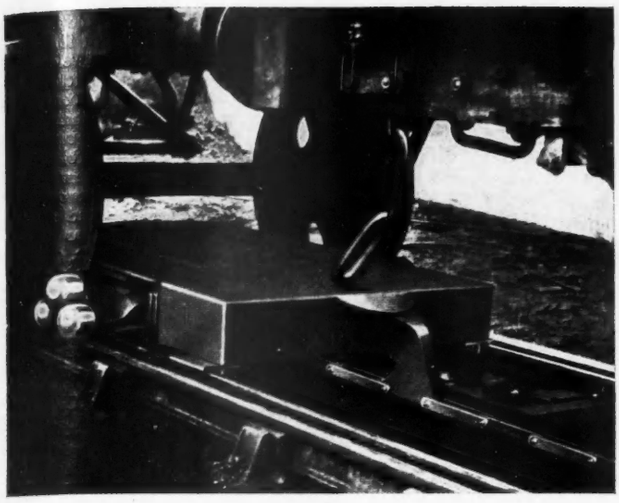


Fig. 4 The Beetle runs on auxiliary rails between the normal track rails, and is hauled by a chain. The retractable arms engage the wheel treads and the heads of the rails.

wagons, however, it was useful to have an additional man to precede the wagons to ensure the safety of personnel at level crossings, in production bays, and under gantry derricks. This additional man also speeded up shunting, and detailed job analysis had shown that the double-manned locomotive was in almost every case amply justified.

FLANGE WEAR ON WHEEL TYRES

Dealing with flange wear on locomotive wheel tyres, he pointed out that the wear and tear on flanges varied with the number of points and crossings, the average weight of the load moved, the gradients, the amount of sand put down, the skill of the driver in stopping and starting, the wheel arrangement and the wheel-base. It was only a few days' job to have the tyres turned down but this nearly always occurred at awkward times.

Experience at Mr. Tatterson's works showed that after fourteen months' service the wear at the flange roots of the wheels of a new 500-h.p. 50-ton Diesel-electric locomotive operating ingot car trains of 750 tons over new track with several sharp curves and a short gradient of 1 in 120, was ⅜ in. The middle wheels, like all six-wheelers at Shotton, were flangeless. The Steel Company of Wales were using bogie-type locomotives to avoid the problem, but this involved a further £10,000 per unit. Flange lubricators had recently been fitted to three large locomotives at Shotton, while on curves rail lubricators were also being used to reduce the wear on both the track and the flanges.

A second paper on other aspects of the same subject was then read by Mr. R. S. Brunton (Steel Company of Wales, Limited). He first described an unusual difficulty arising from cases of serious erosion in cylinder liners, possibly caused by impingement attack associated with high-velocity turbulence of the cooling water, impingement of air-laden streams, and electrolytic action. The condition of the eroded cylinder liner is shown in Fig. 1. The use of normal water treatment had proved relatively ineffective, and silicon-coated liners were being tried following partially successful attempts at spraying with a high-purity molybdenum base covered with 18 per cent. nickel-steel coating.

On engine lubrication, Mr. Brunton pointed out that serious carbon deposits occurring in cylinders, around piston rings, valves and valve seats caused leaks, undue wear and scoring of cylinder walls, and could lead to structural failure. Series I detergent oils inhibited this carbon coagulation, and the Steel Company of Wales were now using them exclusively. Detergent oils were particularly valuable for use in supercharged engines with higher B.M.E.P. where greater cylinder head temperatures and pressures occur. These oils were, however, more expensive and required special filters. Worn engines consumed more of this oil, and laboratory analysis of additive content was difficult.

Series II detergent oils were now available for use in engines where B.M.E.P. exceeded 140 lb. per square inch, and in all large two-stroke engines with high piston-crown temperatures.

NUMBER OF MEN ON SHUNTING

The discussion which followed showed that Mr. Tatterson's remarks on the number of shunters employed per locomotive had aroused considerable interest. One representative contended that a second man might be justified in old and congested works but not in a modern layout. Another opinion was that in heavy traffic conditions—with a train of 20 or more wagons—the addition of a third man might well be justified. This speaker went on to suggest that a possible alternative would be to provide an extra shunter on the ground at sidings, representing in effect a third man for every locomotive train using those sidings. There was general agreement that the best policy was a flexible one, manning strength depending on the nature of the individual job. In any case consultation with the unions concerned would be essential before any major changes in manning standards were introduced.

Discussing flange wear, one speaker commented that this depended largely on track curves, which implied that a better performance lay very much in the hands of the track designers. There was general agreement that flange lubrication offered considerable possibilities for reducing wear, and it was also suggested that flame-hardening might extend flange life. During the discussion it emerged that Mr. Tatterson's ideal of a three-year "life" before treatment was within sight of realisation, several of the delegates having achieved from 14 months to two years at their works.

The meeting agreed that running the engine while the locomotive was not working was a most unsatisfactory way of maintaining a reasonable temperature in the cab, but some doubt was expressed as to the desirability of installing small solid-fuel stoves. The fire risk, although remote, still troubled some of the delegates, and it was generally felt that adequate heating was primarily the responsibility of the builders, who might well study it further.

WHAT SIZE LOCOMOTIVES ARE NEEDED ?

The second session was opened by Mr. E. R. S. Watkins (Appleby Frodingham Steel Company) with a paper on "Best Sizes and Numbers of Locomotives Required in Works." He gave a classification of steam and Diesel locomotives as follows:

Steam		*Diesel*	
Light	Up to 14 in. by 20 in. and 30 tons (4 or 6 wheel)	Light	Under 200 h.p. and 30 tons
Light medium	15 in. by 22 in., 30-35 tons (4 or 6 wheel)	Medium	200-300 h.p., 30-40 tons
Medium	16 in. by 22 in., 35-40 tons (4 or 6 wheel)		
Heavy medium	16 in. by 24 in., 40-45 tons (6 wheel)	Heavy	300-400 h.p., 40-50 tons
Heavy	18 in. by 24 in., 50-60 tons (6 wheel)		
Special	From 18 in. by 24 in. and 60 tons (6 wheel)	Special	Over 400 h.p. and 50 tons

Mr. Watkins pointed out that the choice of locomotive size depended on the starting, low speed and continued effort required, and on any local restrictions on the track. Locomotives should be heavy enough to start and stop average loads with ease, and all commonly encountered loads without difficulty. It might be desirable to limit lengths of trains for ease in shunting and communications, and to reduce the time at focal points, thus possibly reducing capital and running costs and simplifying the manning problems.

The 15-in. and smaller steam locomotives should be considered obsolescent at the larger works. The 16-in. (four-wheeler) could work in restricted surroundings but would only meet all essential requirements in large level works with difficulty. The 16-in. (six-wheeler) would meet all internal requirements readily in most large works, but might require supplementing with 18-in. types for uphill loads. Larger types were only required for exceptional indivisible loads and gradients.

Diesels under 200 h.p. could only be used for certain purposes but 200- to 300-h.p. Diesels would meet all medium combinations of train weights and inclines, and could work in restricted surroundings. Diesels of 300 to 400 h.p. were generally equivalent to the larger 16-in. and 18-in. steam locomotives ; the over-400-h.p. Diesels would cover exceptional loads and gradients.

The number of different sizes and types of locomotives should be kept to a minimum. Every additional size or type caused a loss of interchangeability and standardisation, particularly of maintenance. The minimum variety, however, allowing for replacements progress,, etc., was probably two predominant classes, plus some residue of earlier classes and the beginning of a new class.

The number of locomotives required at a parti-

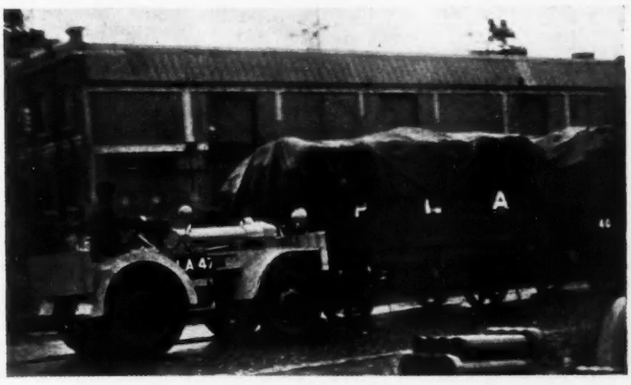


Fig. 5 A tractor fitted with a buffer beam can be used for the larger rakes of wagons.

cular works would depend on :—

(*a*) Traffic tonnage and conditions.

(*b*) Promptness of service; reserve power might be necessary to meet peak requirements, or average power might be used continuously on a priority basis.

(*c*) Uneven requirements; a minimum number of locomotives could handle a given traffic tonnage evenly over 24 hours, but there was usually a peak of day-time traffic in a works which required additional power on day work of two shifts.

(*d*) Reliability of service; reserve power must be available in case of breakdowns, etc.

(*e*) Maintenance; withdrawal for a day's shed maintenance should not be less than once in 14 days, so that one relief locomotive was required for each 13 locomotives in use.

(*f*) Movement without locomotives; more material was being moved by road, and wagons were being shunted by light auxiliary devices. However, greater economies might be possible by using compact railway layouts with intensive shortened locomotive movements.

POWER COMPARISON OF STEAM AND DIESEL

Mr. R. T. Ribbons (Steel Company of Wales) continued with a paper on "The Determination of Locomotive Sizes," which he intended primarily as a guide to those who had an existing steam fleet, which would shortly be replaced by Diesel locomotives. Unlike steam locomotives, Diesels were known by their engine horse-power; it was therefore difficult to make a size comparison, particularly as Diesels developed horse-powers near to their maximum over a wide range of speeds. The steamer, however, could store up energy for release over short periods, as in fly shunting. Any attempt to equate cylinder sizes to engine horse-powers would lead to a wide variation in results and a more theoretical approach was preferable.

Locomotive weight was directly connected with the maximum tractive effort required. Diesel locomotive manufacturers gave a maximum tractive effort of between $\frac{1}{4}$ and $\frac{1}{3}$ of the locomotive weight, irrespective of the horse-power.

The tractive effort required could readily be calculated knowing the loads, inclines and curves throughout the works, and was equal to the rolling resistance (the force required to maintain the train at constant speed on the level) plus the incline resistance (the extra force required to propel the train up the incline), i.e., tractive effort required = (weight of train and locomotive) × (resistance per ton)

$$+ \frac{\text{(weight of train and locomotive)} \times 2{,}240}{\text{gradient}}$$

For normal British Railways stock the following figures give the resistance :—

Speed in m.p.h.	Starting	1	2	7	11	17
Resistance in lb. per ton	20	7	7	7·5	8	9

The locomotive weight should be taken as at least four times this calculated tractive effort.

The horse-power required would depend entirely on the speed at which loads were to be moved and was equal to

$$\frac{\text{(tractive effort)} \times \text{(speed in m.p.h.)}}{375}$$

Contrary to common belief very little horse-power was needed to start even the heaviest of trains. Mr. Ribbons gave examples showing calculations of horse-power for various train loads, speeds and gradients.

The effect of lowering the horse-power was merely one of reducing speed, and even with very low horse-powers, providing the locomotive was heavy enough, built for low speeds and had a continuous tractive effort/speed curve, stalling would not occur.

At the Steel Company of Wales, a 300-h.p. four-wheel locomotive weighing 45 tons could handle general works traffic up to 1,000 tons without difficulty on the level. For larger locomotives, working on inclines, bogies were preferred despite the extra initial cost; this was compensated for by the savings in maintenance and overhaul costs.

A subsequent speaker suggested that the 40-ton 0-6-0 locomotive was probably the most popular model in steelworks use. Always provided the curves on the local track system were not too sharp, necessitating expensive bogie equipment, the six-wheeler was, in the speaker's opinion, to be preferred on the basis of capital costs.

There was general agreement that the size of a locomotive fleet ultimately depended on the traffic-operating policy—the choice lying between a fleet large enough to cover all transport requests instantly, or a smaller number of engines which meant accepting the consequent inevitable delays to some traffic.

Another speaker stated that his firm's experience showed that one Diesel unit was equivalent to 1·33 steamers, or three Diesels equalled four steamers. It was interesting to note that this evaluation coincided with the results of the analysis given in the studies of utilisation and availability by Brisby and Turnbull in their earlier paper.

Another point emerging from the discussion was the direct bearing of the standard of maintenance on the size of any locomotive fleet. One speaker said that although output was actually increasing, his firm had nevertheless managed to reduce their fleet from 67 to 59 engines as a result of special attention to maintenance.

ELECTRICAL, MECHANICAL, AND HYDRAULIC DRIVES

Mr. R. J. Fett (North British Locomotive Company, Limited) then delivered a paper on "Diesel Locomotive Drives—Electrical, Mechanical and Hydraulic." He opened with the premise that for transport purposes the Diesel engine must be coupled through a robust transmission system to obtain the necessary torque for starting heavy loads, to obtain the full engine horse-power over the speed range, and a smooth output torque together with high efficiency. Most works transport requirements could be met by power ratings of 100 to 500 h.p. and mechanical, hydraulic and electrical transmission could be used.

The fluid coupling was common to both mechanical and hydraulic systems and took the place of the conventional friction clutch, providing smooth take-up of the drive during acceleration without the wear and tear of friction clutches. It consisted of two similar units with radial vanes on the input and output shafts. The coupling was filled with a fixed amount of oil, and driving power was obtained by the absorption and release of kinetic energy in the fluid as it gathered and lost rotational velocity. The traction coupling was operated with a constant quantity of oil and was developed specially for road and rail vehicles, but was also applicable to winches, cranes, excavators, etc. The scoop controlled coupling gave greater flexibility of control but with some generation of heat, the quantity of oil in circulation being varied at will.

For 100 to 400-h.p. shunting locomotives the Wilson epicyclic gearbox with three, four or five speed ratios was used. The gears were applied by adjustable brakes to the requisite gear train, each having its own air cylinder and actuating mechanism.

For 100 to 600-h.p. locomotives, the S.L.M. oil-operated geared transmission had been used; it consisted of two outer portions rigidly bolted together forming a gearwheel which could rotate freely on the white-metal surface of the inner members, held in contact with the outer members by oil pressure, thus engaging the clutch. When the pressure between the plates was released, a small back pressure forced the inner members together to disengage. Power to the final drive was transmitted through a bevel pinion and two crown wheels on either side of a reversing dog-clutch.

The Voith-North British hydraulic transmission, described in ENGINEERING for June 15, 1951 (vol. 171, page 720), had been used for many years for 100 to 1,500 h.p. and was a development of Fottinger's original hydraulic torque converter. A combination of torque converters and fluid couplings, or just converters in multiple, were used. The torque converter could be likened to a single-stage reaction turbine. In the fluid converter, as distinct from the mechanical converter (gearbox), the input torque and speed remained constant at all road speeds, despite changes in output torque as output speed varied. Control was by throttle, giving a variable output torque automatically matched to the load.

The British Thomson-Houston electric transmission was used on 150 to 500-h.p. locomotives and comprised an engine-driven generator directly coupled to the Diesel engine, two axle-suspended traction motors of the four-pole commutating pole type and a simplified system of controls. The latter usually consisted of a cam-operated power controller, two single motor reversers coupled together, three single-pole magnetically-operated contactors to open and close the two motor and the generator circuits, and a series-parallel battery switch. The generator rheostat was operated by a hydraulic motor driven by oil under pressure and controlled by a torque valve linked to the engine fuel bar, giving a smooth variation of speed and tractive effort over the whole range.

The main discussion on Mr. Fett's paper centred round maintenance. The point was made that the Diesel-electric locomotive necessitated two distinct types of maintenance, mechanical and electrical, with a consequent expansion of repair and maintenance facilities.

It was also suggested that the atmosphere at most steelworks, which would not affect mechanical or hydraulic systems noticeably, could lead to a deterioration of electrical drives.

Another speaker emphasised that Diesels had not been in use in steelworks for a sufficient length of time to provide reliable comparative cost figures. However, he went on to quote the experience of British Railways who reckoned maintenance costs on Diesel-electric locomotives working 6,500 hours annually to be about 2*s.* per locomotive-hour.

There was a measure of agreement that most locomotive drivers preferred electrical or fluid drives because of the simplicity of operation and the short training required. For this reason drivers tended to recommend these types at the expense of the mechanically-driven version.

The meeting generally agreed that hydraulic transmission was probably the most suitable. On the whole, in the power range up to 500 h.p. there was not much in it, but there was certainly scope for controversy when considering the larger types.

SHUNTING DEVICES OTHER THAN LOCOMOTIVES

The final paper was delivered by Dr. H. R. Mills, head of B.I.S.R.A.'s Plant Engineering Division, the subject being "Shunting Devices other than Locomotives."

Dr. Mills pointed out that to use a locomotive fully it was essential to ensure that it was reasonably loaded, in addition to reducing its idle time to a minimum. Small loads of one or two wagons could often be moved by other machines, thereby releasing locomotives for heavier work. Such machines fell into two groups: mobile self-propelled machines running either on or between the rails and usually on pneumatic tyres, and machines fixed at a particular site for operating within a limited range. The latter were more suited for a new layout or when extensive alterations were proposed.

The first group comprised :

(*a*) Small hand-guided mobile machines with petrol engines for moving a few loaded wagons. These ran on one rail and propelled the wagon by one corner. A pneumatic-tyred variation of this type is shown in Fig. 2. It was described in ENGINEERING for July 25, 1947 (vol. 164, page 93).

(*b*) Two-wheeled shunting machines for push-

ing or pulling, which ran on pneumatic tyres either between the rails or astride one rail. These could be battery or petrol driven.

(*c*) Ordinary pneumatic-tyred Diesel or petrol tractors fitted with a buffer beam across the front for larger rakes of wagons. One of these is shown in Fig. 5.

Details of these machines are set out in Table V; total running costs varied between £20 and £50 per week.

TABLE V.—*Haulage Capacity and Speeds of Machines.*

Machine	Capacity on straight (tons)	No. of loaded 27-ton wagons on straight	Approx. speed (ft. per min.)	
			Full wagons	Empty wagons
Small truck mover ..	75	2	35	60
Large truck mover ..	150	4	180	260
Shunting machine	120	3	170	220
Petrol shunting tractor ..	200	5	280	440
Diesel shunting tractor ..	200	5	280	440

For sidings feeding a tippler, existing or artificial gradients were usually employed so that individual wagon movements could take place without the assistance of locomotives or other machines. Unless the site sloped naturally, wagons were pushed up the initial incline by locomotives or other wagon movers, such as capstans, or mules running on rails or slides usually engaging with the axle of the wagon. (The Wagontroler, illustrated in Fig. 3, and described in ENGINEERING for July 2, 1954 (vol. 178, page 26) is such a wagon mover). One type of mover had retractable arms which engaged with the treads of one pair of wheels. A machine of this type is the Beetle, made by Strachan and Henshaw, Limited. It is illustrated in Fig. 4, and was described in ENGINEERING for June 20, 1952 (vol. 173, page 795). Another type, used on the new Quebec, North Shore and Labrador Railway for pushing wagons up an incline to a tippler, ran down into a pit so that the next wagon could be run up over it. At this yard, wagons were moved to the foot of the incline by a side-arm pusher locomotive which ran on narrow-gauge rails between tracks.

Tipplers in gravity systems could be used in several ways :—

(*a*) On naturally inclined sites, at the middle of the slope, so that empty wagons ran on down-hill.

(*b*) On level ground, so that the wagon was released at a higher level running down to the empty sidings.

(*c*) Sited at the highest point so that wagons had to be hauled up to the tippler, thus ensuring a good control of wagons at the tippler and so preventing any damage.

Gradients must be steep enough to ensure the free running of all wagons. Modern marshalling yards had an initial gradient of about 1 in 20 flattening out after about 150 ft. to approximately 1 in 60. Suitably spaced retarders would probably be necessary to reduce the speed of the wagons that ran most freely, such retarders usually operating by friction against the wagon wheels. One type had friction surfaces operated by levers depressed by the wagon itself.

Wagon traversers had been installed on colliery sidings; these ran transversely to the tracks and would transport a wagon from one line to the other. By providing shunting devices of the types described, aided by improved layout of sidings, it might be possible to reduce the number of locomotives required or to employ these more fully on other duties.

In the subsequent discussion on Dr. Mills' paper one speaker said that when contemplating the purchase of these auxiliary devices a careful balance should be observed so that the "idle time" of locomotives was not unnecessarily increased. The fullest use of the locomotive fleet—representing a much greater capital "lock-up" than the smaller units—should be a prerequisite to the introduction of auxiliary methods.

ADVANCING THE TECHNIQUES OF WELDING

CURRENT WORK OF THE B.W.R.A.

The British Welding Research Association, whose headquarters are at 29 Park-crescent, London, W.1, held their annual general meeting and Open Day at the research station at Abington Hall, Cambridgeshire, on July 12. At the luncheon which followed the meeting the speakers were Mr. Clifford Paine, Sir Charles Lillicrap, Dr. J. H. Paterson and Mr. W. W. Watt.

In his speech proposing the toast of the Association, Mr. Paine (who is Director of Research and Development at Imperial Chemical Industries, Limited) made the point that research without development was sterile, and that technology must go hand in hand with theory. The importance of team work, he thought, could be overrated: there was considerable need for individual thinking. Small organisations certainly had a part to play in the give and take of knowledge, and if there were overlapping in the work done by different bodies, this could often have a stimulating effect on both sides.

The present buildings at Abington Hall house only the engineering section of the work. However, a new building is in course of construction to which the metallurgical section, now at Park-crescent, will be transferred. With a floor area of 13,000 sq. ft., the new building will allow for a much-needed expansion of this section. At the Open Day, in order that this important section should not be forgotten, a number of exhibits were displayed in a marquee. Among these was a series dealing with the problems of hydrogen inclusion with resultant porosity and fissures.

WELDABILITY OF LIGHT ALLOYS

Weld cracks also formed part of the exhibition and a new method of assessing the weldability of various light alloys has been developed, a method which is both quick and inexpensive. It is called the "fishbone" test from the appearance of the specimen, a small sheet of the alloy concerned (measuring approximately 3 in. by 1½ in. and less than ⅛ in. thick) with a series of saw cuts, increasing in length, running inwards on both the long sides. A line of welding is then made down the centre of the plate, starting at the end where the cuts are shortest, and the resultant thermal distortion causes the weld to crack along part of its length. The length of crack so formed is a measure of the suitability of the materials of the plate and the filler. As each test can be carried out in a few moments and needs very little material, it is possible to do a sufficient number to make a statistical analysis of the results. In this way, the compatibility of materials can be quickly and accurately assessed. It is proposed to investigate the possibilities of extending this test to include metals other than the light alloys on which it has been developed. Futher particulars of the method are to be published shortly.

Another of the exhibits from the metallurgical section was the application of the self-adjusting arc process to steels. This is one of the more recent developments in arc welding and in it a bare wire is fed at high speed through a gun. The speed of feed and consumption are kept such that a constant arc length is maintained. The arc is shielded with argon. The method has proved very successful for light alloys, but porosity troubles have been encountered when it is used with steel. This is believed to be due to entrapment of carbon monoxide in the weld pool, an occurrence which at present can be avoided only by the use of deoxidants. Unfortunately, the introduction of these as a coating on the wire is not possible when argon shielding is used, and it is therefore hoped that a solution may be reached by a correct choice of core wire. Better results for the method generally have been obtained by using a generator in which the output current varies considerably for a small change in arc length.

WIDE-PLATE TESTS

Investigation of brittle fracture is being carried out on the wide-plate testing rig which has now been in operation for a year. This machine will take plates up to 36 in. wide and 1 in. thick, and is capable of applying an evenly-distributed tensile load of 600 tons to them. The load is carried by four hydraulic capsules and there is provision for extension of up to 0·4 in. Series of tests have been carried out on this rig on the initiation and propagation of brittle fractures in welds. Such fractures appear to be sensitive to temperature, which determines whether the fracture occurs in a brittle manner or not. At the critical temperature, the method of initiation, by a notch or direct load, does not matter. Initiation can also take place due to residual stresses alone. Loading the plate to the yield point appears to relieve these stresses and to prevent brittle fracture.

In the fatigue-testing laboratory, an alternating torsion machine has been constructed for carrying out tests on thin-gauge box-sections of the type used in automobile design. This type of section can also be subjected to alternating bending stresses in a machine of the resonance-vibration type. In this the specimen is supported at the node positions and is excited at a frequency near its natural period by a mechanical oscillator at one end. Stresses are measured by resistance strain gauges.

HIGH-FREQUENCY PULSING PRESSURES

One of the most recent machines is that which is being used to apply high pulsing pressures inside thick-walled pipes. It was developed at the University of Bristol. The pressure within the pipe is produced by filling the specimen with liquid and then forcing a ram (mechanically driven) into it. In the machine installed, pulse pressures of 45,000 lb. per square inch can be generated at a frequency of 800 cycles per minute. The test is being used to compare various welding methods as applied to thick-walled pipes.

Under the heading of pressure vessels and pipelines, tests are being carried out on the reinforcement of openings in welded storage tanks, and on branch reinforcement as well as other subjects. It has been found that varying the proportions of the reinforcement round a branch-pipe has little effect, but that a great improvement can be obtained if the plate is mounted inside the vessel, or even if the end of the pipe itself is allowed to project inside. These tests are being continued using pipes of different wall thickness and of different proportional scales.

Several examples of crack-detection were being shown in the laboratory where non-destructive testing is carried out. The main work here is the development of a reference block intended to be used as a standard for ultrasonic testing. It is designed to serve the dual purpose of facilitating the adjustment of ultrasonic equipment and to standardise the conditions of test to allow comparisons to be made. Two reference blocks were being shown, one designed by B.W.R.A. and the other by the Röntgen Technische Dienst of Holland. Detailed comparison of the performance of the two blocks is being made. Work in this section is proceeding in the use of magnetic detectors and of penetrants, both fluorescent and dyes. In radiography, the panel set up to consider the subject feels that better radiographs can be obtained if the welds are inspected in the dressed condition, rather than in the rough state after fabrication.

CONTROL VALVES OPERATING AT REDUCED FLOWS

MODIFICATIONS FOR MAINTAINING SENSITIVITY

Occasionally in automatic-control installations circumstances arise when it is desired to reduce the capacity of a valve without a corresponding reduction in body size. An example of this is when, for some reason, a plant has to run for a long period, greatly below its full capacity, and the valves normally used cannot give the required accuracy of control at the reduced flow. Reduction in "trim" as it is called has also been used in the field to correct a mistake in ordering, as a result of which the valve installed was much too large for the duty. The method of reduction in double-seated automatic valves is carried out by fitting smaller-bore seating rings in the body and using a smaller-diameter plug to correspond.

The Crosby Valve and Engineering Company, Limited, Ealing-road, Wembley, Middlesex, together with their associates, Mason-Neilan Regulator Company, of Dorchester, Boston, U.S.A., have studied this question and have produced a standard design of reduced trim, known as the "point 4 factor trim." Their analysis has shown that (1) *reduced capacity trim must be designed with reduced seating diameter, and* (2) *that only one size of reduction is practical for a given size of double-seated valve. Their findings and discussion of the matter are given below.*

There are many valid reasons for specifying reduced-capacity plugs and rings for control valves as well as several not too easily justified. Perhaps a brief review of the reasons with appropriate comments will be a helpful reminder.

Entire plant installations designed to operate for some extended period at greatly reduced flows. This is a valid reason, but one which is likely to be improperly handled. There is a tendency, for example, to specify reduced trim when full-sized trim would easily handle both flow requirements.

Correction of existing valves badly oversized on the original specification. This may be a valid reason—but only when (as will be demonstrated) the field service conditions cause the control valve to run excessively close to the seat.

To obtain an "expanded outlet" section in a valve to reduce the effect of flashing. Reduced trim under these circumstances could be classified as full-size trim in an expanded body. On flashing fluids, the chief restriction may be the body outlet passages. Reduced plug and seat ring construction in a larger body is a sound approach to this problem. The velocity of mixtures of vapour and liquid under certain conditions may be very high and the erosion problem severe.

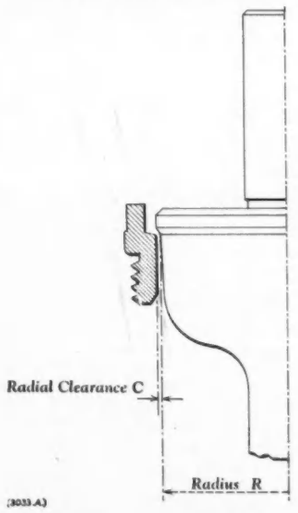


Fig. 1 The minimum controllable flow is proportional to the circumference multiplied by the radial clearance.

To increase the cross-section of the outlet passages in the body to reduce noise. On high pressure-drop steam service, for example, there is evidence that fluid velocities must be held down to prevent objectionable noise. The criterion is body outlet velocity. The nominal valve size is chosen to limit this velocity and reduced plug and seat ring specified if necessary.

For very severe high pressure-drop services to give additional strength to the working parts. Reduced trim always carries the diaphragm motor, guide diameter and stem diameter of standard trim. On a 6-in. reduced trim valve against a standard 4-in. valve, for example, the diaphragm motor effective area increases from 100 sq. in. to 150 sq. in., the stem size from $\frac{1}{2}$ in. to $\frac{5}{8}$ in., and the plug guides from $1\frac{1}{8}$ in. to $1\frac{1}{2}$ in. This adds substantially to the power, strength and stability of the valve.

Installations where an increase in body size is desirable from the standpoint of mechanical strength. Once in a while a small control valve must be installed in a large line. An increase in body size may be indicated here to prevent distortion due to line stresses.

High-pressure alloy valves where it is more economical to use a line-sized valve than to pay for special flanged reducers. This is an occasional *bona fide* requirement especially on 900-lb. ASA and 1,500-lb. ASA valves used on hot-oil service in refineries.

Use of $1\frac{1}{2}$ in. by $1\frac{1}{4}$ in., 3 in. by $2\frac{1}{2}$ in. and 6 in. by 5 in. size designations to fill a supposed need for one valve size for each listed nominal pipe size. This is not a valid reason for specifying reduced-area trim. The reduction in capacity is not sufficient to justify a special design.

MINIMUM CONTROLLABLE FLOW

In determining whether or not to specify reduced area-trim, the important factor is the minimum flow at which the valve will control satisfactorily. After all, if a practical design of valve could be produced which would control down to 1/1,000 of its maximum, the problem would not arise.

The minimum controllable flow (with the plug just off the seat) is directly proportional to the clearance between the plug and the seat ring (Fig. 1). This is true of any plug whether solid turned or skirted, with equal percentage, linear, or parabolic characteristics. The clearance is determined largely by the mechanical problem of alignment between the various body subassembly components, with an allowance based on experience to take care of operating temperature extremes. It is this clearance area which determines the minimum usable flow of the valve and it is usually expressed as a percentage of the maximum, or as a ratio, e.g., 50 to 1. With the valve nearly closed, the passage open to flow is an annular ring which is very narrow with respect to the seat-ring diameter. For this shape the port area is equal to the seat-ring circumference times the radial clearance ($2\pi RC$), Fig. 1. For a double-seated valve, the clearance area is the sum of both ring areas.

If the seat-ring diameter is halved, the potential seat area is one quarter of the original. The seat clearance, which determines the minimum flow, is only one-half of the original (Fig. 2). This means that the seat-ring diameter must be cut substantially to make a reasonable reduction in minimum flow. The total seat area in conventional double-seated valves is larger than theoretically necessary (i.e., two 2-in. diameter seat rings in a 2-in. nominal valve). This was done many years ago to reduce the required lift on bevel-seated (quick-opening) discs used on direct-acting regulators, and in the smaller sizes to allow for an adequate centre post. This extra circumference is now used to advantage in improving the flow characteristics on equal percentage valves. Using the full stroke of the standard trim, a more than proportionate cut in seat diameter can be made when designing reduced-capacity trim.

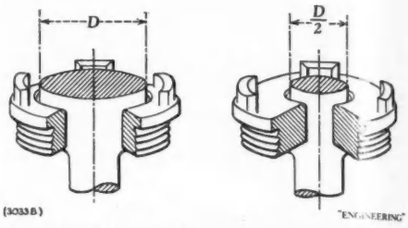


Fig. 2 Halving the diameter quarters the area but only halves the clearance area.

In practical design, the maximum potential flow range of the valve is established by the plug-to-seat clearance. In a 1-in. double-seated valve with, say, 0·002 in. radial clearance, the minimum is about 1/50 of the maximum. As the valve size increases, the maximum potential flow increases as the square, but the leakage flow, since it is primarily dependent on seat circumference, does not increase as rapidly.

Now, 0·002-in. radial clearance is approaching the lower practical design limit in a 1-in. valve. For the 10-in. size on a direct ratio basis the clearance would increase to 0·020 in. This is more than necessary even with ample allowance for slight misalignment of parts and for temperature effects. This means that the larger the valve, the easier it is to obtain a low percentage minimum flow. In this size, with the clearance held to the practical minimum, the usable flow range increases to probably something over 100 to 1. The important point is that the clearances as established for the various valve sizes are the minimum usable on normal service.

The shape of a valve plug is chosen to control the rate-of-flow change per unit of lift. With a percentage characteristic the smaller clearance slightly alters the rate of flow increase per cent lift. The full line in Fig. 3 shows a theoretical 50-to-1 equal-percentage valve characteristic—and the effect of a reduction in clearance to one-half the required figure by the dotted line. The alteration of the characteristic would be scarcely noticeable, although the useful range of the valve is increased.

With a linear-characteristic plug, the problem is identical, since the minimum flow again is determined by the plug-to-ring clearance. The less the clearance, the more nearly the realisation of the linear characteristic.

The point established is that the minimum controllable flow in any valve is a direct function of the seat-ring diameter. Except in special designs, the plug-to-seat clearance is always held to a minimum.

NOMINAL VALVE SIZES

There is a tendency when considering flow problems from a theoretical standpoint to

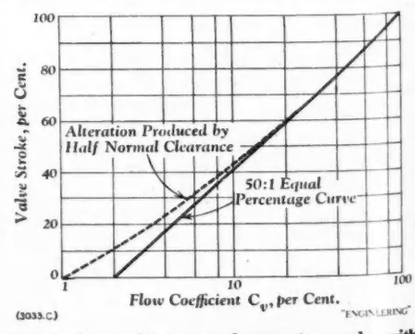


Fig. 3 Flows for an equal-percentage valve with reduced clearance.

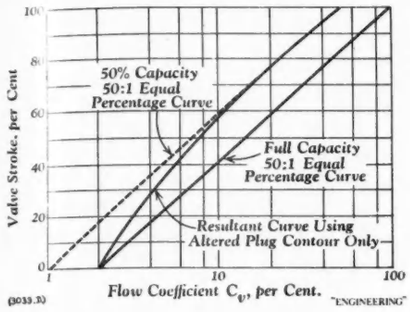


Fig. 4 Flows for an equal-percentage valve with reduced stroke and altered contours.

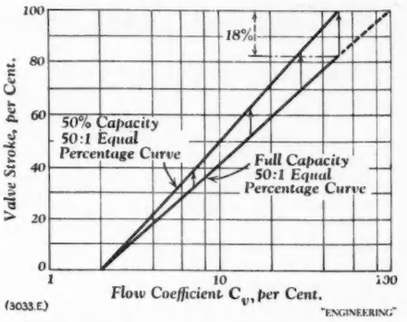


Fig. 5 Effect on flows of reduced stroke.

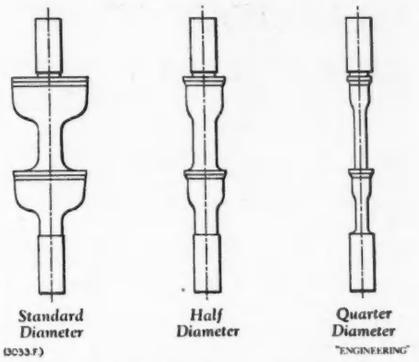


Fig. 6 Effect of reducing plug diameter.

become confused by the economic issue. The chief reason for the large number of pipe sizes available to-day is the price difference between successive sizes. As the pipe diameter is increased, the wall thickness must also be increased for the same pressure rating, and as a consequence the cost goes up quite rapidly. This fact, coupled with the use of nominal inches for sizing, has resulted in a number of pipe sizes which would not exist if flow requirements alone were the principal consideration.

The ¼-in. linear-characteristic piston valve has over three times the maximum capacity of the ½-in. piston, yet there has never been an objection to this relatively large jump between sizes. The control problems in this size range are generally identical to those in larger systems. It is quite reasonable to say that, since these two plugs have been used in large quantities for years without any sizing problems due to intermediate flow conditions, then in theory, all valves could be treated similarly.

With modern flexible controllers, excellent operating-air output characteristics are obtainable throughout the entire stroke of the control valve. There is no reason why a valve should not be permitted to operate at 5 lb. per square inch or 13 lb. per square inch continuously, or even to approach the limits of the valve stroke more closely during peak conditions. The only possible problem is the sudden discontinuity which would occur if the valve actually came right down on the seat.

We can conclude from these considerations that a series of seven valves, of sizes 1 in., 1·6 in., 2·5 in., 4 in., 6·4 in., 10 in., and 16 in., would adequately handle the vast majority of all control applications. Each would have approximately 2½ times the capacity of the previous size. While this is an absurd approach from an economic standpoint, it is quite reasonable on the theoretical side. Certainly, the intermediate pipe sizes, such as 1¼ in., 2½ in., and 5 in., need not be considered in determining valve port sizes.

REDUCED CAPACITY DESIGN

There are three basic methods for obtaining reduced-capacity trim in a double-seated control valve: (1) standard seat rings in combination with a plug with substantially reduced port area; (2) standard seat rings and plug with reduced valve stroke; (3) reduced-diameter seat rings and plug with standard stroke. Of these designs, it will be shown that only the last one can be considered practical. The final design is resolved into a single percentage reduction which simplifies specifications.

The first method will be considered briefly since it is used commercially today. The flow characteristics of such a plug in which the capacity at rated stroke is cut to 50 per cent. of normal are shown in Fig. 4. The flow characteristic of the full-capacity plug is drawn as equal percentage from 2 per cent. to 100 per cent. The desired reduced-capacity flow curve is shown as a line parallel to the full-capacity curve from 1 to 50 on the graph.

If the plug port contours are designed for the 50 to 1 reduced-flow range, and the seat ring to plug clearance gives 2 per cent. initial flow, the resultant flow curve will run from 2 per cent. to 50 per cent. on the graph as shown by the heavy curved line. At strokes above 60 per cent., the reduced trim requires 18 per cent. more lift to produce the same flow. As the stroke decreases below this point, this difference in valve stem position would gradually diminish to zero as the plug approached the seat. This means that the only gain accomplished by this design is a reduction in the maximum capacity of the valve. Service life, stability of control, and ability to handle low flows are not sensibly altered.

The second method is to shorten the rated stroke of the valve. This is much simpler than a special plug construction. If both designs produce identical operating characteristics, it becomes very difficult to justify the special modified plug design even for simple maximum capacity reductions. In Fig. 4 the reduction to 50 per cent. capacity represents about 18 per cent. reduction in stroke. By substituting in the diaphragm motor a spring which is 18 per cent. stiffer, the capacity of the nominal sized trim can also be halved.

Fig. 5 shows the flow characteristics of the 50 per cent. capacity curve produced by this 18 per cent. reduction in valve stroke. The resultant curve is a straight line from 2 per cent. to 50 per cent. when replotted on a per cent. stroke basis. There is no practical difference between this curve and the one produced by altering the plug contour. If a valve positioner were used, the same effect could have been obtained by a slight adjustment in the multiplying linkage in the positioner. The net effect would be a slight alteration of the basic sensitivity of the valve. Thus a well-designed double-seated valve of full nominal size will do anything to be expected of any reduced-trim design based on full seat ring diameter.

Since there is no real gain in any design of reduced trim utilising full diameter seat rings, the problem is reduced to the third method, that of determining a seat-ring diameter which will give a minimum controllable flow substantially less than that for the full-capacity trim. With the smaller seat-ring diameter the plug to seat-ring clearance can in most cases be reduced to give an additional gain. Fig. 6 shows a scale drawing of a standard 4-in. double-seated parabolic plug. The centre figure shows a reduced area design based on one-half of the standard seat ring diameter. With the plug to seat ring clearance the same for both designs, the clearance area or minimum controllable flow is reduced one-half. The seat diameter is still large enough to permit a maximum C_v* of about one-half of that for the full-area trim. The mechanical construction of the plug is good. It is in fact a practical reduced-trim design. To make a second reduction of equal magnitude the seat diameter would have to be halved again and the resultant plug design is shown in the third sketch.

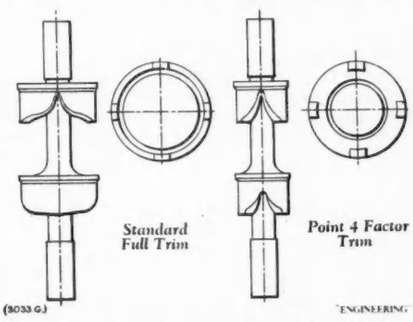


Fig. 7 Comparison of full-trim and 0·4 factor trim plugs.

From these sketches it can be seen that there is a definite limit in the practical reduction of seat-ring diameter. As the ring diameter is decreased beyond a reasonable minimum, plug design rapidly becomes absurd. Since the full-size body is being retained, the plug length, the distance between the guides, and the stroke remain constant. The mechanical construction of the plug must be substantial to withstand severe service conditions. This figure clearly indicates the limitations of seat-diameter reduction if rugged construction is to be realised.

With this limitation in mind, the actual seat-ring diameter reduction on the reduced trim-design was chosen. The actual reduction on valves up through 3 in. is 30 per cent. on the diameter. Valves 4 in. and over were reduced 40 per cent. The amount of reduction was dictated by the physical construction of the plug. Fig. 7 is a scale drawing of the 4-in. full-capacity and reduced-capacity per cent. V-port plug.

POINT 4 FACTOR TRIM

With the seat-ring diameter thus fixed by the practical constructional dimensions, the principle problem remaining is the selection of the percentage reduction in flow capacity. By analysing the problem from the viewpoint of field application as well as engineering design, it has been determined that a 60 per cent. reduction in capacity is the best solution. The multiplying factor for the reduced trim then becomes 0·4. This reduction is reasonable and takes full advantage of the reduced seat diameter and clearance. In other words, the percentage reduction in flow has been determined largely by the capacity obtainable from these reduced-diameter rings while maintaining desirable flow characteristics.

A series of turned plugs with a linear characteristic and V-port plugs with a percentage characteristic have been designed on this basis and are now in production. There need no longer be any reference to nominal size reductions. If the maximum demand on any application exceeds 40 per cent. of nominal valve capacity, full-area trim should be specified. If for any of the various reasons outlined in the earlier section, the maximum required flow coefficient is not more than 40 per cent. of nominal valve rating, Point 4 Factor Trim should be specified. For very special applications involving large valve bodies and small flows, special single-seated construction must be considered.

* C_V is the valve flow coefficient or the rated flow capacity of a valve expressed in U.S.G.P.M. of water at a pressure drop of 1 lb. per square inch across the valve.

RAILWAY TRACTION OIL ENGINES

FOR LOCOMOTIVES WITH CONTINUOUS OPERATION UP TO 2,000 B.H.P.

British Railways modernisation plans have stressed the increasing use that is to be made of Diesel locomotives, and firms with appropriate experience in their production will no doubt be kept busy over the next few years. One such firm is Davey, Paxman and Company, Limited, Colchester, who have introduced a series of engines from 750 to 2,000 brake horse-power, evolved specifically for line-service locomotives which have to meet conditions of high mileage at high load factor.

A 12-cylinder V prototype engine of 1,500 brake horse-power was completed in the summer of 1950, and since that time has been thoroughly tested over many thousands of hours, including well over 2,000 hours at brake mean pressures of 150 lb. per square inch or over. Various changes in detail have been made within this time to make the engine better suited to railway requirements; the combustion system has also been re-designed, to make the exhaust clean from low fractional loads up to 10 per cent. overload.

The basic production model was ready in 1952, and many of these engines have been built and sold for industrial and power-generating purposes. The YL range has been offered on the railway market with all the refinements and details characteristic of modern traction practice, and with either three-point or four-point mounting of engine or engine-generator group as may be desired. The pressure-charged 8YLX is shown in an exploded view in Fig. 2.

The present range follows the original ideas of six years ago in having 8-, 12- and 16-cylinder V models with an angle of 45 deg. between the banks, of 9¾ in. by 10½ in. cylinder size, and of 1,000 r.p.m. Both naturally-aspirated and pressure-charged models are built as standard, with the outputs shown in the accompanying Table; but intercooling gives further increases, and development work to meet traction conditions has been undertaken.

MEDIUM WEIGHT AND COMPACTNESS

Fig. 1 shows the general characteristics; and from the table and figure will be appreciated a dictum of the designers, that medium weight rather than ultra-light weight was deisrable, as locomotives rather than railcars were the applications in view; and that compactness, particularly in width at cylinder head level, was to be regarded as a desideratum, the dimension here being 70 in. for the naturally-aspirated engines and 74 in. for the pressure-charged models, with a dimension considerably less at the frame structure. Heights, too, are quite moderate, being 27¼ in. below crankshaft centre line and 62 in. above it. The rotational speed of 1,000 r.p.m. also is high enough to prevent any disadvantageous effect on the main generator size and weight when Diesel-electric propulsion is favoured. Finally, the specific fuel consumption is seen to be even, varying only from 0·385 to 0·375 lb. per brake horse-power-hour the whole way down the full-load scale from 1,000 to 475 r.p.m.

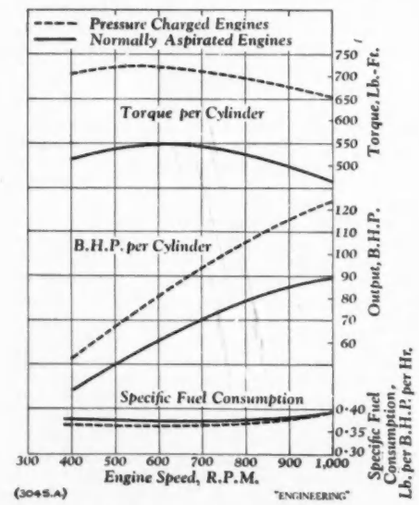


Fig. 1 Performance curves for the Paxman YL and YLX railway traction oil engines. The specific fuel consumption is very even for both pressure charged and normally aspirated engines.

In the naturally-aspirated form the compression ratio is 15 to 1 and the full-load firing pressure about 950 lb. per square inch; pressure-charged, the compression ratio is lowered to 12·8 to 1. Injection pressure is about 3,500 lb. per square inch. Respective specific outputs at 1,000 r.p.m. are 6·93 and 9·73 brake horse-power per litre, naturally-aspirated and pressure-charged.

DETAILS OF ENGINE CONSTRUCTION

In these YL engines the bedplate, which also form the sump, is stress-bearing and carries the main bearings as well as the mounting feet. The crankcase-cylinder block above is also a one-piece welded steel structure for all models; and, like the bedplate, is fully stress-relieved and shot-blasted before machining. Large aluminium covers are provided on each side of the crankcase-cylinder block to give ease of inspection of main and big-end bearings. These inspection covers are fitted with crank-case-explosion doors, set to blow open at 20 lb. per square inch; this pressure gives no distortion and the doors automatically clamp down again immediately the pressure wave is over, and so prevent ingress of air. Pressed aluminium inspection covers are fitted for inspection of the water jackets and cooling water piping connections.

The water jackets are separate heavily-galvanised units surrounding the cast-iron liners, and by this means the cooling water is kept away from the welded steel crankcase-cylinder block. Also, any water leaking past the neoprene ring sealing up the bottom of the water space does not drain into the crankcase, but into an "air" chamber from which the drainage is to atmosphere.

Each cylinder head is an individual iron casting housing two inlet and two exhaust valves. A double deck is cast in the cylinder head to deflect the water at high velocity past the exhaust valves and upwards round the centrally-located five-hole injector; the water leaves the head at the uppermost point. The inlet ports are divided in order to promote unidirectional swirl in the combustion chamber, and this is one of the factors assisting the clean exhaust.

The valve rocker gear consists of aluminium drop forgings; lubrication of the overhead gear is from the engine main system, and the drains from the upper face of the cylinder head lead direct to the crankcase interior and not to the exterior, so giving a clean engine. Only one camshaft is used, located in an oil trough in the neck of the V and driven by a duplex chain from the back end of the crankshaft. There are two cams per cylinder, and each is keyed to the shaft by two taper keys. The shaft itself is in one piece, and runs in thin-walled steel-shell white-metalled bearings. The cam followers are die-cast aluminium bronze.

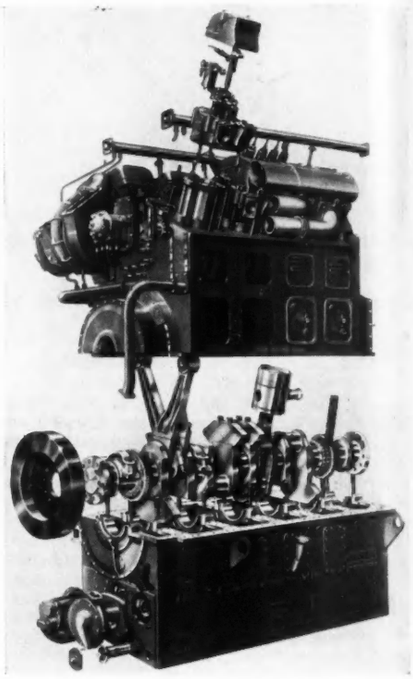


Fig. 2 An exploded view of the 8YLX. This is a V-form, eight-cylinder, pressure-charged engine with a maximum traction rating of 1,000 b.h.p. at 1,000 r.p.m.

The fuel injection pump camshaft and tappets, gear-driven from the valve camshafts, have a lubrication system entirely their own, which does not use the normal engine oil, to prevent dilution by fuel oil. This system is fed by a small pressure pump gear-driven from the main camshaft, which obtains the oil from a small sump built into the engine crankcase; this auxiliary lubricating system also has a filter of its own. The fuel injection pumps themselves are of the C.A.V. individual flange-mounted type carried in two groups parallel to the cylinder centre lines on a shelf above the main camshaft trough. Ermeto connections are provided at the pump and injector ends of the fuel pipes. The fuel lift pump is driven from the free end of the injection pump driving shaft, through two small flexible couplings and an intermediate shaft.

A single-piece forging of En12Q steel is used for the crankshaft, the webs having balance weights as needed for the various four-throw, six-throw and eight-throw models. A feature is that a double bearing is provided at each end, to support the weight of the main generator at the back end, and to support the weight of the viscous vibration damper and give adequate support for auxiliary drives at the forward end. All bearings are the same and are interchangeable, except the one flanged locating thrust bearing. Bearings are of steel shells, copper-lead lined. At one end of the shaft the sprockets for the duplex timing chain are carried between the two rear bearings; and at the forward end the gear drive to the lubri-

TABLE I. CHARACTERISTICS OF PAXMAN YL AND YLX ENGINES

Model	N.A. or P.C.	B.H.P.	Cylinder Bore and Stroke, in.	R.P.M.	Brake Mean Pressure, lb. per sq. in.	Piston Speed, ft. per min.	Dry Weight, lb.	Dry Weight, lb. per b.h.p.	Gross Weight with Water and Oil, lb.
8YL	N.A.	710	9¾ × 10½	1,000	90	1,750	20,300	28½	21,300
12YL	N.A.	1,070	9¾ × 10½	1,000	90	1,750	27,700	26	29,100
8YLX	P.C.	1,000	9¾ × 10½	1,000	126	1,750	22,300	22½	23,300
12YLX	P.C.	1,500	9¾ × 10½	1,000	126	1,750	29,200	19½	30,600
16YLX	P.C.	2,000	9¾ × 10½	1,000	126	1,750	38,700	19½	40,500

N.A. = Naturally aspirated. P.C. = Pressure charged

cating oil pump is taken off between the two bearings. The flanges at each end of the shaft are exactly the same; and the same viscous vibration damper is standard for 8-, 12- and 16-cylinder engines.

LUBRICATION SYSTEM

The lubrication system is conventional in principle. The interior main pipes are integral portions of the bedplate structure, and there are no interior pipes of the normal type. In each main bearing housing there is a magnetic plug to retain any small ferrous particles, and adequate provision is made for cleaning all oil passages. The pressure pump is located externally at the front of the bedplate.

The lubricating oil delivered from this pump is taken, via a coarse strainer, to the radiator, thence to a full-flow filter which is protected by a safety valve normally set to 80 lb. per square inch. From the filter the oil is fed to the cooler, then to the main gallery running down the full length of the bedplate. By this means all lubricating oil is cooled and filtered immediately before entering the main gallery, and the capacity of the filter is enough to ensure a minimum pressure drop, moderate velocity and optimum efficiency. A pressure-relief valve in the main rail controls the engine oil pressure at 50 lb. per square inch for the supply of oil to the main bearings, big ends and the governor. At each end of the main rail is a pressure-reducing valve which supplies oil at 10 lb. per square inch to the camshaft, rocker gear and drive, and the camshaft driving chain.

Two exterior water circulating pumps (one in the eight-cylinder engines) are gear driven from the free end of the engine. These centrifugal pumps have a cast iron casing housing a bronze impeller on a stainless steel shaft; a ball thrust bearing is used in conjunction with a plain bush journal and suitable glands. Inlet manifolds are mounted in the cylinder housing, and a flexible connection is tapped off the inlet manifold and connected to each cylinder liner individually. Outlet manifolds are connected to the heads by short lengths of pipe and flexible connections, and are located above the V between the cylinder banks.

GOVERNING AND PRESSURE CHARGING

The centrifugal hydraulic servo governor is driven by bevel gears off the drive end of the main camshaft. Engine lubricating oil is the medium employed for its operation. Incorporated within the governor casing are three solenoids which normally provide a range of eight different engine speeds. By this means a small, compact and sensitive governor has been provided.

A torque control regulator is fitted and operates in conjunction with the engine governor. It consists of an hydraulically-operated rheostat, the movement of which is regulated by a torque control valve within the governor. This torque control valve includes two moving elements provided with ports, which are linked to the engine rack control shaft and the governor speed setting lever respectively. A change in external load causes the engine governor to change its position, thereby affecting the relative positions of the torque control valve elements, and uncovering ports to feed the hydraulic motor driving the rheostat, thus causing it to rotate in the direction necessary to adjust the electrical load until it is equal to the rated engine output.

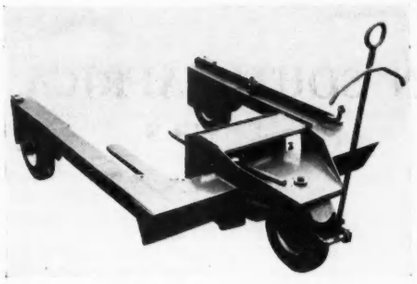
Pressure-charging, using Napier turbo-blower units is used on three of the five engines listed in Table I. The eight-cylinder and 12-cylinder models have two turbo groups, and the 16 YLX engine has four. On the 12-cylinder model are fitted the MS.200 type, of 15,750 r.p.m. continuous speed and 17,000 r.p.m. maximum speed, and on the 8- and 16-cylinder models the MS. 100 type, of 20,000 r.p.m. continuous speed and 21,000 r.p.m. maximum speed, both suited to a maximum gas temperature of 649 deg. C. They are carried on the ends of the crankcase-cylinder block by welded-steel brackets. Valve overlap in the pressure-charged engines is 130 deg.

A practical feature of the Paxman YL engine is the high degree of part standardisation throughout the range. About 75 per cent. of all wearing parts are standard throughout the five engines in the range, and are built and machined to strictly interchangeable limits so that one stock of spares is sufficient for a railway's requirements for everything from heavy shunting locomotives up to the largest main line locomotives.

* * *

PALLET-CARRYING TRAILER

For the quick and economical transport of goods stacked on pallets or stillages, Lansing Bagnall, Limited, Basingstoke, Hampshire, have developed a self-loading fork truck which can be used as a trailer. These trailers consist of a framework mounted on three wheels within which are the forks for lifting the pallet. Raising and lowering the forks is carried out hydraulically and the lever for the hand pump can be seen above the single wheel in the illustration.



Fitted with hydraulically operated lifting arms, this trailer can carry a pallet or stillage with a 1-ton load.

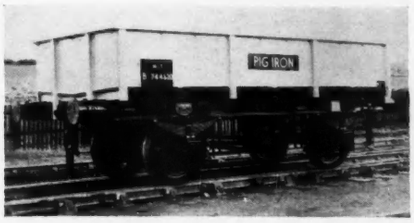
The capacity of each trailer is 1 ton and the lift of the forks 6 in., so that stillages as well as pallets can be handled provided their size does not exceed 48 in. square. To pick up a load, the trailer is manoeuvred so that the side arms straddle the pallet and the forks slide underneath. The latter are then raised by the pump and a hinged bar swung across the open end of the side arms to prevent the pallet slipping off. In addition, this bar carries a coupling hook at the centre enabling trains of the trailers to be built up. A ring in the end of the handle allows it to be used as a towing bar. All three wheels have pneumatic tyres and the trailers can be drawn by any type of tractor.

* * *

WAGON FOR PIG-IRON TRAFFIC

British Railways have recently completed the first of a new series of wagons that has been designed to carry pig iron. The new wagon, shown in the accompanying illustration was built at Shildon Works, County Durham. The design has to be extremely robust as somewhat abnormal loading conditions are encountered in this particular traffic. Pig iron is produced on a belt system and the pigs are discharged from a ramp into the wagon below. At the time of discharge they are still extremely hot, and are sprayed with water during their fall. Therefore the wagon not only has to be strong enough to withstand the impact, but must also be built to allow the water to drain away.

The floor of these new wagons is made of ½-in. steel plate—twice the thickness normally used for mineral wagons—and the sides and ends of ⅜-in. plate. A stiffening capping of 2½ in. by 2 in. angle runs all round the wagon. The length over the headstocks is 17 ft. 6 in. and the width 8 ft. The depth at the sides is 2 ft. 6 in., increased by the slope of the floor to 2 ft. 9 in. at the centre. Along the centre line of the floor is a series of slots, 1½ in. wide and extending almost the whole length of the wagon, to permit the water to drain off.



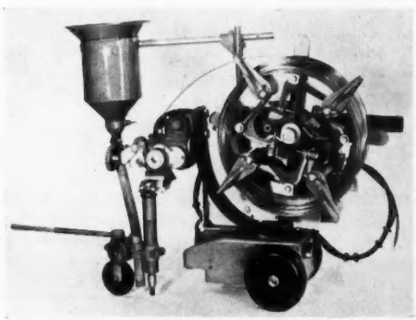
The new British Railways 30-ton pig-iron wagon has been designed to withstand shock loading conditions.

The wheels are 3 ft. 1½ in. in diameter and are mounted to give a wheel base of 10 ft. The tare weight is 9 tons 7 cwt., allowing a useful load of 30 tons of pig iron without exceeding the 40 tons permissible load for two pairs of wheels.

* * *

SPRING-LOADED REEL FOR ELECTRODE WIRE

In order to overcome the difficulties involved in holding loose and random-wound coils of electrode wire, the Quasi-Arc Company, Limited, Bilston, Staffordshire, have developed the expanding reel shown in the illustration. Long coils of wire are needed in Unionmelt and similar continuous welding processes and a loose-wound coil on a rigid reel tends to become unmanageable as it unwinds.



The outward pressure caused by the springs prevents the coil of electrode wire from becoming unmanageable as it is unwound.

The reel that has been developed has four spring-loaded arms to which are attached the plates making up the drum surface. The continual pressure of the springs prevents the turns of the coil from slipping and so increasing in diameter. Coils may be slid on to the reel by releasing and rotating the four fingers which make the sides. Eccentrics fitted on these fingers can also be rotated to give an effective variation in reel diameter of 2 in.

* * *

INDEX TO "ENGINEERING"

Volume 178 now ready

The Index to Volume 178 (July-December. 1954) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36, Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the list need not re-apply.

An aerial view of the new works of Babcock and Wilcox at Duncanville, South Africa. The company in Africa is an autonomous unit for making, erecting and servicing boilers supplied by the company throughout the continent.

BOILER MAKING IN SOUTH AFRICA

TRAINING SCHEMES AT ALL LEVELS

A boiler-making works has recently been established at Duncanville in the South African Transvaal by Babcock and Wilcox, of Africa (Pty.), Limited. Although the parent company has had interests in South Africa for many years now, the African Company was not registered until 1945; it is, however, an autonomous unit, and the decision to go ahead with the works was taken in 1948.

The obvious choice for such an enterprise was in the Transvaal, the centre of heavy industry in South Africa. The site of 46 acres purchased at Duncanville, Vereeniging, allowed ample room for subsequent expansion, and the works as a whole have been laid out bearing in mind the addition of future buildings and services.

The work consists of four production bays and a number of auxiliary buildings, detailed below, and shown in the aerial photograph reproduced above.

WORKSHOPS

Drum Shop.—The drum shop is 450 ft. long and 60 ft. wide. It is equipped with a 40-ton overhead travelling crane and plates are bent on a set of heavy rolls which have a capacity for bending plates up to 2 in. thick. There is also a large edge-planing machine in this shop.

Drum welding is by the multilayer process, developed at Renfrew, and the welding machine illustrated below was designed and built in the Renfrew works. It has electronic control of the arc voltage to within plus or minus 1 volt. The submerged-arc welding process is also used. As in the parent company's works, every inch of weld is subject to X-ray examination, and a mobile X-ray unit operating at 400,000 peak volts is used.

Structural Shop.—The structural shop, having the same dimensions as the drum shop, is equipped with a 20-ton crane, and has facilities for the manufacture of all forms of plating and structural work normally associated with boiler contracts.

Tube and Pipe Shop.—The tube and pipe shop is the same length as the other two units but is wider, two 80-ft. bays being available in order to accommodate the long and awkwardly-shaped tubes which often have to be handled. It is equipped for cold bending tubes from 1¼ in. to 4½ in. in diameter. It is also equipped for the hot bending of tubes and pipes up to any size and for close bending of superheater tubes, a large surface table being available for laying out pipe work. This department is also equipped for flash welding tubes and for the automatic studding of tubes by resistance welding.

Plant Shop.—The plant shop, which is well equipped with machine tools and forge equipment, including a large air hammer, is at present located in a portion of the structural bay.

Stores.—There is a main under-cover stores bay 120 ft. long by 80 ft. wide, but outside store yards are also used.

Subsidiary Buildings.—In addition to outbuildings, the South African climate allows some work being undertaken in the open, and a certain amount of fabrication is carried on outside, next to the rail-loading bays.

Water for hydraulic power proved a considerable problem in the planning stage, due to the high cost of mains water. A well was therefore sunk on the site, and water is pumped from a depth of 170 ft. at a rate of about 700 gallons per hour for hydraulic power and cooling purposes, the mains water being restricted to washing and drinking.

There is a producer-gas plant which has an output of 10,000 cub. ft. per hour of gas for furnace-heating purposes. A separate coal-fired furnace is used for stress-relieving completed drums.

Other portions of the site accommodate a large office building, together with washing and changing facilities, and canteens for both European and native workers. In addition to these amenities, it was necessary to build a number of houses and flats to meet the housing situation.

ERECTION AND SERVICING

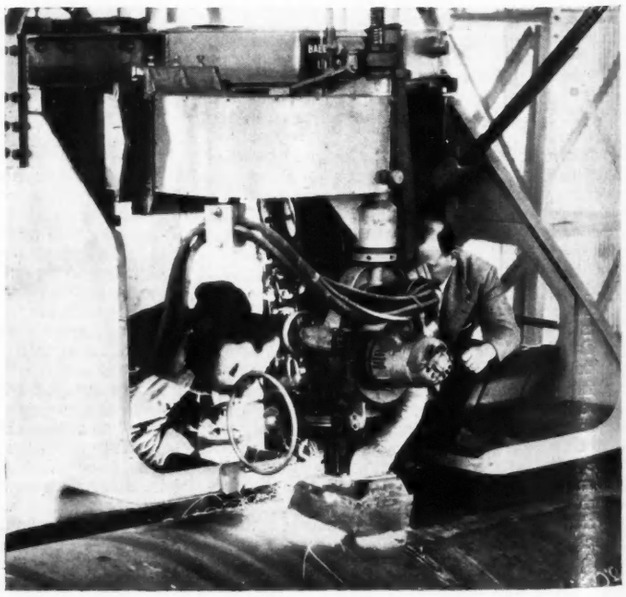
The Erecting Department, whose headquarters are at the works, is responsible for providing all the necessary labour for erection of the company's boiler plant throughout Southern Africa, and for the provision of experienced supervisors for concerns in the remoter parts of the country which prefer to employ their own labour. The Department employs more than 600 Europeans and 1,600 natives. In addition to the provision of the necessary labour, the Department is also responsible for their welfare at site, and this, in the case of isolated sites, has often involved elaborate transport arrangements as well as additional housing schemes.

Commissioning and after-sales service is an extremely important aspect of boiler manufacture, and a large and well-equipped service department is based on Duncanville to undertake commissioning in all parts of the country, the instruction of the clients' engineering staff in the handling and maintenance of new plant, carrying out efficiency tests, and the rapid investigation of any combustion defects or breakdowns. The comprehensive system of records that is kept is invaluable in the design of new installations.

TRAINING SCHEMES

Boiler making is not merely a specialised branch of heavy engineering, it is an industry in which the manufacture-client relationship is on a very special basis. A boiler cannot be sold through a local merchant, dispatched in a number of bundles and boxes, and then forgotten. Expert knowledge and constant contact with the client are necessary in all stages, from the preliminary inquiry onwards; and no aspect is more important than that of after-sales service. It has, therefore, always been the company's policy to be directly represented wherever practicable.

Since the African company is a self-contained unit and not an immigration agency, training of new recruits is of vital importance, the methods used being largely the same as are employed by the parent company. These various schemes provide for training at all levels, i.e., apprentices, craftsmen, and technicians. There are also special courses for University graduates, and these post-graduate courses include valuable experience spent with the parent company at Renfrew, Scotland, and in the London head office.



Among the plant installed for the fabrication of the boiler drums is the Babcock multi-layer welding machine.

FLAME-HARDENING OF BEARING SURFACES

PROLONGING LIFE OF DIESEL CRANKSHAFTS

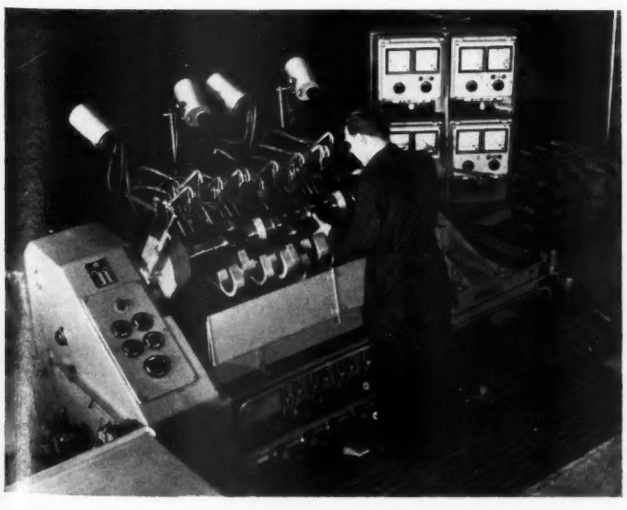
The ever-increasing power output of the Diesel engine throws heavier loads on the pins and journals of the crankshaft. To resist the extra wear the area of the bearing surfaces must be increased or the shafts must be made from heat-treated alloy steels. Both methods increase the cost, and a more satisfactory solution may be to surface harden crankshafts made from steel containing 0·4 to 0·5 per cent. carbon. Bearing surfaces of pins and journals with a hardness figure of Rockwell C 54-60 can easily be obtained, giving the crankshaft a long life and a tough core which has not been affected by through heating. The surface hardening process for crankshafts has been used with success at the Lincoln works of Ruston and Hornsby, Limited, and the accompanying illustration shows the plant. The process used was developed by Peddinghaus, of Gevelsberg, Germany, and is distributed in this country by Surfard, Limited, Abbey House, London, S.W.1. Descriptions of the process have been given in ENGINEERING for April 29, 1955 (vol. 179, page 544) and February 29, 1952 (vol. 173, page 268).

The illustration shows clearly the main parts of the installation. Above the crankshaft is the heating unit, which consists of sets of water-cooled copper burners for each crankpin and journal. The burner incorporates three heads with slots to cover the width of the zone to be hardened. In the case of a two-cylinder crankshaft five sets are used, two for the pins and three for the journals, whilst for a six-cylinder crankshaft 13 sets are used, six for the pins and seven for the journals. The quenching unit, shown below the crankshaft, is provided with an equal number of spray quenches. The crankshaft to be hardened, which is made from En.12 steel, is held between centres on a movable carrier having three positions that are controlled by the operator.

The hardening operation is commenced by loading the shaft in the neutral position midway between the burner and quench units, the position shown in the illustration. By moving the shaft into the heating position, the gas and oxygen valves supplying the burners are automatically opened, and the burners ignited from a small pilot jet. This movement also starts the motor used to rotate the crankshaft at approximately 45 r.p.m. The machine is equipped with two master crankshafts of the type to be hardened and to these are attached the burners and quenches, which therefore follow in correct relation the movement of the pins as they rotate. This arrangement allows the two pins and three journals of the two-cylinder crankshaft to be hardened at once, thus saving considerable time. Crankshafts for more than two cylinders have the bearings hardened in groups.

Once the shaft is in the heating position, the Milliscope automatic temperature control comes into service and indicates to the operator the correct moment to move the shaft into the quenching position. The Milliscope comprises a working head which " watches " the job being heated and an indicator panel on which two dials are fitted. In the illustration the four working heads can be seen above the burners and the four control panels are on the right of the hardening plant. The temperature at which the component should be hardened is manually set on the left-hand dial and the needle of the right-hand dial starts moving towards the zero point 25 deg. before the pre-set temperature (in this instance 810 deg. C.) is attained, thus giving a visual warning to the operator that the moment of quenching is approaching. That the temperature is reached but not exceeded is most important because when attained it gives the correct depth of hardening, and to exceed it might seriously affect the properties of the finished job. When the needle reaches the zero point the operating lever is pulled to bring the shaft into the quenching jets, and this movement automatically opens the water valve. At the same instant a variable time switch is set in operation and this subsequently closes the water valve allowing some heat to remain in the material to give a pre-determined back tempering effect and complete drying. The motor for rotating is then automatically switched off as the shaft is brought into the neutral position for removal.

Heating takes 100 seconds and quenching 45 seconds, giving a total time of just under 2½ minutes for a two-cylinder shaft. The depth of hardening can be controlled by adjusting the burners to vary the length of time taken for the bearings to attain the pre-set temperature.



This machine is used to surface harden the pins and journals of crankshafts. The crankshaft is shown in the neutral or loading position, with the burners above and the quench below. The Milliscope heads are above the burners, and control panels to the right of the plant.

STEAM HEATING USING ALUMINIUM ALLOY PIPES

Special Requirements for Oil Tankers

When oils are transported in sea-going tankers the heavier grades need some form of heating to keep them in a condition suitable for handling by the pumping equipment. This is normally done by passing steam through coils in the tanks, and various materials have been used for the steam pipes. Before considering the merits of different materials the somewhat unusual operating conditions should be known.

Whatever material is used must transmit the heat in the steam to the oil as efficiently as possible. It must withstand the corrosive effects of crude oils, high-octane petrol, and sea water; heating is not required for the last two, but the tanks will almost certainly carry both at some time, as respectively cargo and ballast. The heating installation in general must be robust to stand up to mechanical shock due to storms, war-time emergencies, and handling by the ship's crew. It should be capable of being made with the minimum alteration to the ship, and should be at an economic price.

Materials used have been mild steel, cast iron, aluminium-brass alloy and a special aluminium alloy. While all types have certain advantages, Steels Engineering Installations, Limited, 6 Avonmore-road, London, W.14, have found that the special aluminium alloy they have used has proved the most satisfactory. The " Alacoil " system, using pipes made by T.I. Aluminium Limited, was installed in the " British Gratitude " by the courtesy of the British Tanker Company, Limited, and a careful log of its use was kept from October 22, 1953, to April 7, 1955. In that period the following cargoes were carried: light fuel oil, extra heavy fuel oil, marine fuel, Gulf crude, Mina-al-Ahmadi crude, Miri enriched crude and Bahrein fuel oil. The tanks were in sea-water ballast 17 times for a total of 118 days. The oil was heated 17 times, and the total number of hours steaming was 1,556. A more detailed description of the pipes was given in ENGINEERING for July 2, 1954 (vol. 178, page 28).

The tests showed that the heating efficiency of the Alacoil installation was greater than that of a " control " installation of cast-iron pipes, also in the British Gratitude. The installation was examined after nine months and again after 18 months, a section of pipe being taken away at both times and replaced by a new one. At the last examination it was virtually impossible to tell which pipes had just been installed and which had been in use for 18 months. There was no sign of electrolytic corrosion, which was almost certainly due to the special insulating brackets used. A special and patented method of jointing the pipes to the flanges also proved most satisfactory, and the installation was proved to be perfectly steam-tight at the 18 months examination. Steels Engineering Installations have already made installations on a further 12 ships.

* * *

FLATNESS MEASURED BY AIR GAUGING

The problem of assessing the flatness of sensitised photographic plates has been met by the National Physical Laboratory by the application of air gauging methods. Since it was the surface of the emulsion that was to be checked, contact methods were not usable, nor could light be admitted. In the equipment produced, the sensitised plate is placed, emulsion side downwards on three balls whose points of contact are outside the picture area. Six air jets are spaced below the plate, working at a pressure below ½ lb. per square inch. The resistance to the air from the jets is a measure of the distance between the orifices and the plate surface; variations in resistance are shown as pressure differences by the height of a water column. In this particular apparatus the scale magnification is 2,500 and one division represents 0·00004 in. Comparison of the heights of the six columns thus gives a very accurate measure of the flatness of the plate. The technique could be extended for use with any surface profile.

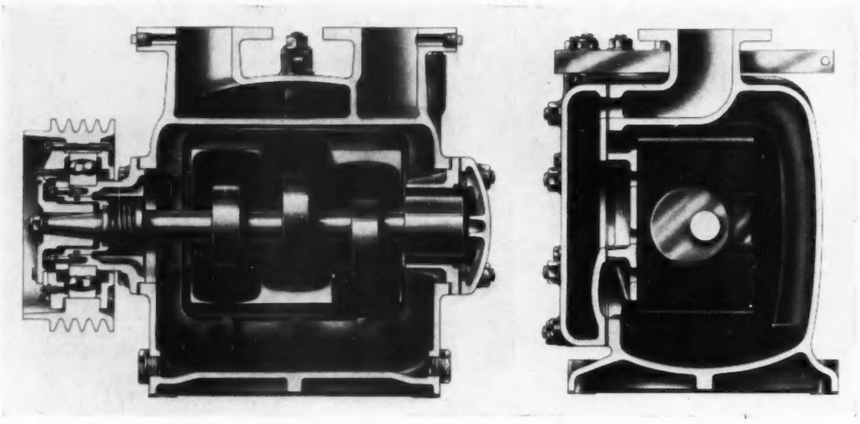


Fig. 1 Sectional arrangement of Megator pump with an output of 110 gallons per minute, showing sliding shoes, eccentric discs, ball bearing and shaft seal.

A NEW RANGE OF MEGATOR PUMPS

IMPROVEMENTS IN MECHANICAL FEATURES AND MAINTENANCE

Megator Pumps and Compressors, Limited, 43 Berkeley-square, London, W.1, have recently introduced a new range of pumps which have the principal working parts in common and are designed for capacities from about 75 to 300 gallons per minute or from 25 to 80 tons per hour on marine rating.

These pumps operate on the firm's sliding shoe principle, which embodies three plastic displacement chambers or shoes lined with synthetic rubber. The pumping action is derived from the rotation of three eccentric discs set at 120 deg. to each other which fit closely into the shoes. The motion of each eccentric disc can be resolved into horizontal and vertical components, of which the former provides the displacement, the disc in effect reciprocating in the shoe like a piston in a cylinder; while the latter controls the entry and discharge of the liquid by imparting a vertical movement to the shoe. As soon as the pump is started it creates an hydraulic pressure difference which holds the shoe in close contact with a flat plate dividing the suction from the delivery sides. This plate has ports opposite each shoe leading, respectively, from the suction branch and into the delivery branch.

The arrangement is illustrated in Fig. 1 which shows sections through one of the new pumps. As will be seen there are three shoes and the pump is therefore equivalent to one with a triple ram action. In another pattern four shoes are used, rendering it equivalent to a two-cylinder double-acting or quadruple ram pump. The output in each case is from 110 to 150 gallons per minute and the drive is by a V-belt. In other patterns two sets of pumping elements with three and four shoes, respectively, are arranged to work in parallel and are driven by a triangular V-belt, while a further range, with as many as eight shoes, provides outputs up to 300 gallons. Three and four shoe pumps are also designed so that they can be direct coupled to a motor or engine. A typical example of one of these is illustrated in Fig. 2.

SEAL DESIGN

All the pumps have radial-face shaft seals which incorporate a rotating carbon ring and a stationary metallic seat. To enable those parts of the seal which cannot be split to be readily threaded over the end of the shaft in case renewal is necessary, the arrangement shown in Fig. 1 has been adopted. This consists of a single self-aligning ball bearing which takes the whole of the belt pull. The pulley is offset so that it is centrally over the bearing, the inner ring of which is mounted on an extension of the pump end cover. The tapered end of the rotor shaft fits into a hub which is bolted to the pulley. On removing the hub from the shaft, the weight of which is then supported on the seal backplate the seal itself can be extracted without disturbing any other part of the pump. The rotor can also be removed without disturbing the bearing or the V-belt drive.

The ball bearing takes both the thrust from the belt drive and the radial thrust at the driving end of the rotor, which is generated by the hydraulic pressure on the discs. As the tapered end of the rotor shaft lies immediately under the bearing, where the bending movement is zero, only a direct side thrust and torque have to be transmitted at this point.

The other end of the shaft on the belt-driven pumps is carried in a synthetic rubber bearing. On those which are direct-coupled and where there is no radial load, rubber is used at both ends, shaft seals being fitted to keep the rotor in axial balance and to eliminate the need for a thrust bearing. These seals were described on page 24 *ante*.

As the working parts in these pumps are maintained in their correct relative position by the pumping pressure, fine fits or clearances are not required on the sliding shoe mechanism. In fact, the shoes float on the rotor so that wide variations in alignment are possible without effecting the operation. The shaft seals also permit considerable misalignment. It is therefore possible for the rotor to run with considerable clearance in the bearings without affecting the mechanism or seals. To take advantage of this flexibility on the direct-driven pumps the coupling has been designed so that the Metalastik rubber bushes, which unite its links, are deflected through a pre-determined amount by a trailing link mechanism actuated by the radial misalignment.

To facilitate the removal of the front cover for the examination of the shoes and other working parts an arm is mounted on the top of the pump as can be seen in Fig. 2. This, when drawn out, enables the weight of the cover to be taken as it is slid off on to the body studs.

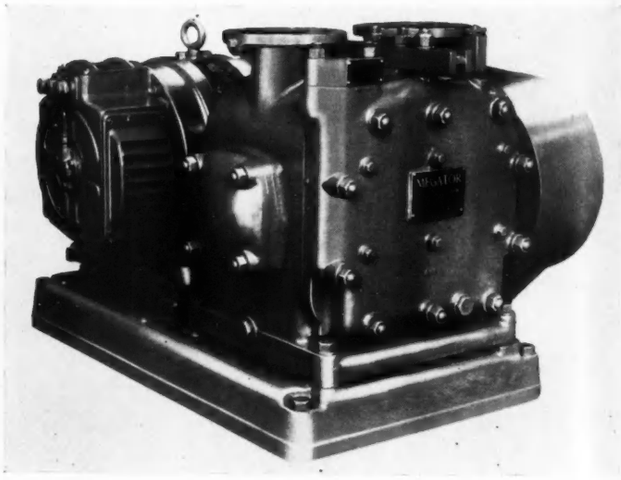


Fig. 2 Typical pump for marine purposes driven by a direct-current motor.

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ELECTRICAL STANDARDS AND METERING

Exhibition at Science Museum, London

A special exhibition has been opened at the Science Museum, South Kensington, London, S.W.7, to coincide with the current meeting of the International Electrotechnical Commission and will remain open until October 31. Although the exhibition is of particular interest to those concerned in the problems of metering bulk supplies of electrical energy, it also serves to demonstrate the care which is devoted to the accurate calibration of electricity meters.

One of the objects of the exhibition is to show the origin and derivation of the various electrical units. An exhibit of particular interest is the complete set of the original British Association Units of Resistance which were made in 1864 for the British Association and constitute the oldest set of accurate electrical standards now in existence.

These "B.A. Units" have been stored for many years at the National Physical Laboratory. It is now hoped that they will be presented formally to the Science Museum, and thus become a part of the national collection of historic scientific apparatus.

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JUNCTION TRANSISTORS

Three more germanium-alloy junction transistors of the p-n-p type have been added to the range made by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. Type EW 58 is intended for low voltage (up to 5 volt) audio-frequency applications. Type EW 59 is for voltages up to 20 and will operate up to about 0·5 Mc/s; in Class B about 300 mW can be obtained at audio-frequencies. Type EW 53 can be used up to 10 volts and has a slightly lower performance than EW 59. All three are hermetically sealed in gold-plated metal cans with overall dimensions of 11 mm. in length by 5 mm. in diameter.

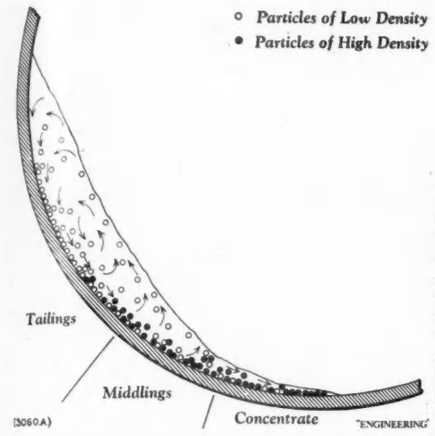

Fig. 1 A section through one of the helices showing the heavy concentrate at the bottom.

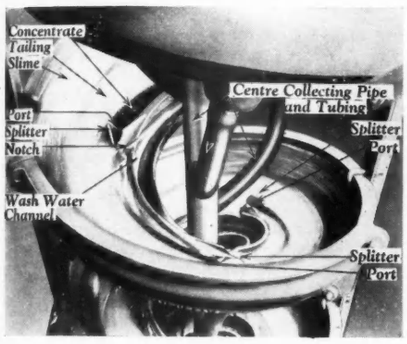

Fig. 2 A view of the helix with slurry and water passing through it. The splitter and the port through which the concentrate is removed are shown at 120 deg. intervals round the helix.

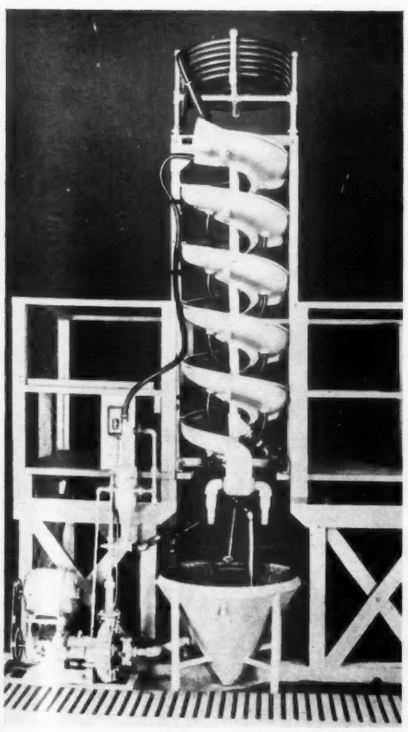

Fig. 3 A helical column, showing the slurry input, the collecting pipes for the concentrate, and the lower end discharge for ore tailings.

CONCENTRATION OF LOW-GRADE ORES

CENTRIFUGAL PRINCIPLE IN HELICAL COLUMNS

Low-grade ores form a large proportion of the world's available minerals, and the concentration of these ores can result in enormous savings because of the reduction in bulk of ore for subsequent transport. The method of concentration should be simple and if possible cheap to run, and the plant must withstand exacting service conditions. Mr. I. B. Humphreys, of Denver, Colorado, invented the Humphreys Spiral Concentrator to meet these conditions, and plants using the Spiral Concentrator are now operating in many different countries. The sales agency for the United Kingdom and certain Commonwealth countries is now held by the Fraser and Chalmers Engineering Works of the General Electric Company, Limited, Erith, Kent.

The Spiral Concentrator is basically a helical conduit of modified semi-circular cross section, the form of which can be seen in Figs. 2 and 3. The material to be concentrated is fed into the top in the form of a slurry, and as the mixture flows downwards the heavy particles concentrate in a band along the inner side of the stream. while the lighter particles travel farther out in the channel with the faster running water. Wash water is added on the inner edge of the stream and flows outwardly across the concentrate band. Fig. 1 shows the double helical action in the flowing stream, with the particles of varying density distributed across the section into concentrate, middlings and tailings. Fig. 2 also shows the concentrate occupying the lowest portion of the helix. Ports for the removal of the concentrate are at the lowest points in the cross section, as Fig. 2 shows, and are located at intervals of 120 deg. The width of the concentrate band removed at the ports is controlled by adjustable splitters. The concentrate is usually removed from the upper part of the spiral through the collecting pipes and tubing shown in Fig. 2, and the middlings are removed from the lower part of the spiral. Ore tailings are removed from the lower end of the helical conduit, which can be seen in Fig. 3. The lower end discharge may be divided by an adjustable splitter into two products; in ore separation, a slime tailing and a sand tailing; in coal preparation, a clean coal product and a middling product.

Particle size, within limits, is not a critical factor in operating the machine and no prior classification is required. Good concentration is generally made on slurries containing liberated heavy mineral particles between 8 mesh and 200 mesh. Size of the low-gravity minerals may range as high as 4 mesh without interfering with the grade of the concentrate. Capacity averages about 1·5 tons of solids per hour per spiral, and pulp volume rate of some 20 to 25 gallons per minute is normal, naturally depending on the character of the feed. Total water requirements vary from 15 to 32 gallons per minute for dilution of the ore to be concentrated and from 3 to 7 gallons per minute of clean wash water.

The action of the Spiral is not so effective when the specific gravity difference of the particles to be separated is less than 1·0. For example, separation is not usually satisfactory between fluorspar (3·2) and calcite (2·7). There are, however, many exceptions to the above generalisation; mica on account of its flaky nature is readily separated from its gangue, and phosphate ore is separated from its gangue by the introduction of a reagent which creates a difference in specific gravity, enabling the Spiral to make a satisfactory separation.

The Humphreys Spiral is not especially sensitive to changes in pulp density, quantity of feed, shape or size of particles or richness of feed. Providing fluctuations are within the range normally expected the Spirals need little attention after the initial adjustment, and recovery and grade are not affected.

The installation of concentration plant of this nature is a comparatively inexpensive operation, because a number of machines can be erected with only an umbrella roof for protection against rain, and no other building is necessary. An equally important factor in the concentration of minerals is the capacity of the plant in tons per square foot of floor space. Humphreys Spirals are commendable in this respect in comparison with concentrating tables, as between 12 and 20 Spirals occupy the same space as one table. The compact nature of a Spirals installation is illustrated in Fig. 4. This shows the plant mounted on a barge; the ore being concentrated is ilmenite, and feed to the Spirals is 600 tons per hour.

Providing that suitable pumps are installed and an adequate supply of water is available, the concentrators are able to work on their own account for 24 hours a day, and a number of installations about the world are operating in this manner. Among the minerals which are being successfully treated by Humphreys Spirals are chromite, ilmenite, lead-zinc ores, iron ores, barites and fine coal.

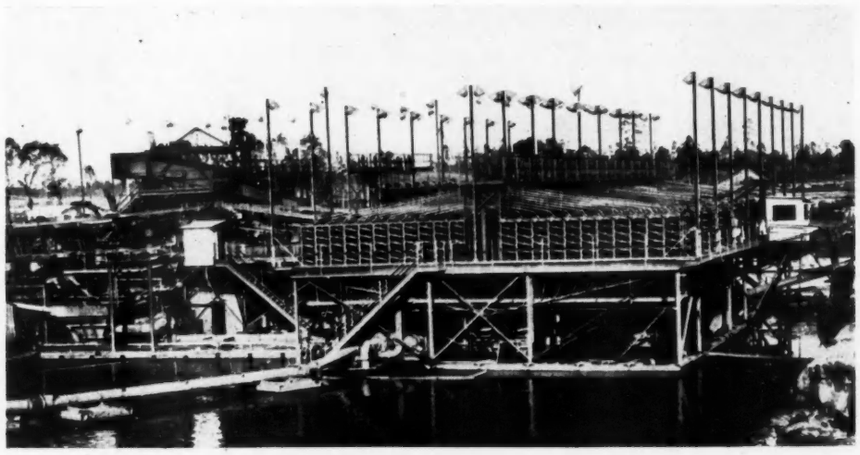

Fig. 4 An installation of concentrators on a barge. The ore being processed is ilmenite, and the feed is at the rate of 600 tons per hour.

Fig. 1 Educational architecture in the United Kingdom embodies the latest in style and construction. Worthing Technical High School is a pre-cast post-tensioned concrete frame with pre-cast concrete panels as cladding.

LIGHT-WEIGHT BUILDING CONSTRUCTION

PRESTRESSED UNITS FOR EASE OF ERECTION

The new technical high school that has been built at West Worthing is one of three planned to serve a large area. It is also a double experiment, in that it has been built to investigate the educational requirements and resulting planning problems of this grade of school and to try out various finishes and materials. In addition, it is an experiment in structural development as it is the first to be built using the " Intergrid " system.

The school has been designed by the Architects and Building Branch, Ministry of Education, in association with the County Architect's Department, West Sussex, for the Worthing Borough Council. The Council agreed to use the school as a prototype for the " Intergrid " system of construction. This system has been designed jointly by the Pre-Stressed Concrete Company, Limited, 171 Victoria-street, London, S.W.1, Gilbert-Ash Limited, 2 Stanhope-gate, London, W.1 (the proprietors and erectors of the system) and the Architects and Building Branch, Ministry of Education. Thus from the outset the team comprised the designers, the manufacturers and the erectors of the essential components. Part of the school is shown in Fig. 1.

The school covers a total area of between 53,000 and 54,000 sq. ft. on an irregular plan dictated by the nature of the site and the accommodation required by the different courses and their interrelation. The main entrance to the school is at its focus. To the south are the administrative headquarters (the left-hand wing in Fig. 1); east, beyond an open court, the main social and communal spaces comprising the assembly hall, dining room and gymnasium; and above it, on three floors, the main group of classrooms. To the left of the entrance, and forming the north flank of the building, are a series of interrelated zones of practical rooms. Light-craft rooms (housecraft, needlework, arts and crafts), partly on two storeys, and workshops (woodwork metalwork and machine shop) occupy the central section of this flank. The north-western end contains science accommodation, linked to a garden-room, greenhouse, cold frames and the school garden. The other end (the north-eastern corner) is the " service " area, containing the kitchen, showers and changing rooms, and the boiler house. The plan thus provides accommodation partly in single-storey, partly in two-storey and partly in four-storey construction.

The " Intergrid " technique was designed initially for buildings up to four storeys in height. It consists of a light prestressed concrete frame combined with standard structural units, which are cast in the factory under strict control and assembled on the site. The system has been designed in accordance with a 3 ft. 4 in. module which also governs the planning grid and allows considerable flexibility of plan shape. An important consideration in design was that the techniques of prestressing should be exploited to the full in order to achieve the utmost elegance and lightness of construction.

SPECIFICATION

Before the development team started work a programme of requirements which the system would have to satisfy was drawn up. The system was required, among other things to:

(*a*) Be capable of four-storey construction; (*b*) conform to a horizontal module of 3 ft. 4 in., thus allowing complete flexibility of plan within a 3 ft. 4 in. planning grid; (*c*) conform to a vertical module of 10 in. and allow flexibility of section, ceiling height, and changes of level in 10-in. increments; (*d*) permit spans of at least 30 ft. under roofs; (*e*) provide an open-frame construction, making it possible to place outer walls, windows, or partitions at will; (*f*) have a self-centering type of floor and roof construction; (*g*) have a cladding system erected from within the building, thus eliminating the use of scaffolding; (*h*) have a full range of internal and external corners without special lengths of cladding slab; (*j*) have the necessary range of components for changes of level in section; (*k*) allow for the use of top lights in the roof structure; (*l*) allow services to pass freely through the horizontal structure between ceiling and roof or floor above (this overall dimension to be 1 ft. 8 in.); (*m*) be entirely of pre-cast units, designed for ease of handling and transport and speedy erection on site; (*n*) provide a structure as free from maintenance problems as possible; (*o*) reduce steel consumption to a minimum.

The roof and floor structure were also considered and it was decided to develop:

(1) An open truss system rather than a hollow slab, because it would allow: a lighter construction; lighter components; the free passage of services in both horizontal and vertical directions;

(2) A two-way grillage system rather than an independent beam system, because: each beam would receive support from its neighbours in both directions, whereas independent beams act in isolation; it would provide a better distribution of loads; deflection would thus be considerably reduced; a greater margin of safety would be achieved; a rigid horizontal slab was possible from which the necessary horizontal wind bracing could be obtained.

The floor and roof system which was evolved consists of a two-way grillage of post-tensioned beams at 3 ft. 4 in. centres in both directions, supported on boundary beams and column heads. The columns are at either 6 ft. 8 in. or 10 ft. centres around the perimeter of each structural bay. Actual dimensions of bays are governed by the needs of the plan, within the limits imposed by the maximum spans which are (primary span by secondary span) 23 ft. 4 in. by infinity, 26 ft. 8 in. by 40 ft. 0 in., 33 ft. 4 in. by 33 ft. 4 in. for floors, and 36 ft. 8 in. by infinity and 40 ft. 0 in. by 40 ft. 0 in. for roofs. Subsequent developments in the beam system have enabled these spans to be increased to eight modules for a primary span, 15 for equal primary and secondary spans of roofs and 11 square for the floors.

No fixed scaffolding is required in construction. The columns are erected in small, portable scaffold frames. Once the frame is in place, all other components are fixed from inside the building. The members involved are clearly shown in Fig. 2.

COLUMNS

The columns are pre-cast to a standard section—6½ in. by 4½ in. overall with grooved sides—and varying lengths on a 10-in. module, and are pre-tensioned with four 0·2-in. diameter wires. There are four main types: three for external walls to carry cladding, including types for internal and external corners, and one type

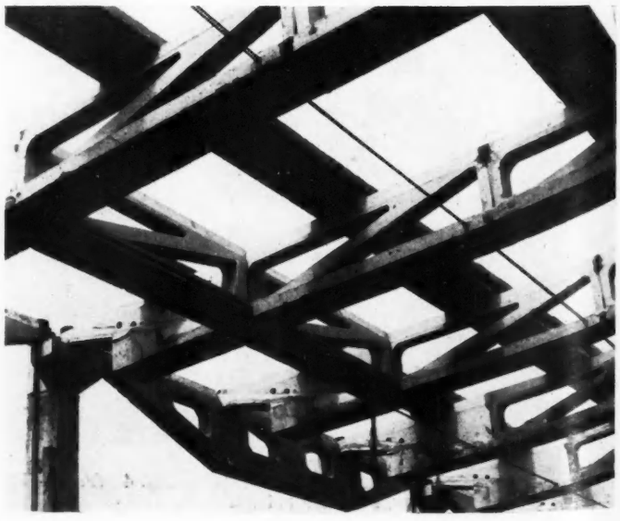

Fig. 2 Structural detail showing the intersection of the columns, perimeter, primary, and secondary beams. The primary beams have been post-tensioned on the ground before erection; tensioning of the secondary beams is completed after the members are in position.

Fig. 3 The panels are dropped in the rabbets and held by reinforced-concrete dowels.

for general internal positions. For multi-storey construction, there is in addition a cruciform type, measuring 6½ in. by 6½ in. along each axis.

Ground-floor columns are designed for erection in sockets cast in the foundation bases. This particular school is founded on piles and in this instance the base sockets are formed as pile caps. On the upper floors the columns stand on the column heads of the ground- and lower-floor columns, and are pin-jointed. All external columns have projecting nibs on each side, and holes cast in at 10-in. vertical centres for the fixing of the cladding and windows. The full range of columns allows for ceiling heights of from 8 ft. 4 in. to 18 ft. 4 in. and changes of level from 1 ft. 8 in. to 10 ft., all in 10-in. increments.

Mushroom-type column heads have been designed to cater for every possible beam-fixing condition which may arise. There are four main types for use with the four main column types. In addition, there is a further range of column heads which provides for changes of level in ceiling structure on opposite sides of any row of columns. These are produced very simply by "stopping off" in the standard production moulds. They are dowelled on to the tops of the columns.

BEAMS

Three types of beam are used to form the floor and roof system: the boundary beams, which are individual in design, and the primary and secondary beams which are both made up of similar types of units.

The boundary beams surround the perimeter of each structural bay. They are of reinforced concrete, and are cast in two standard lengths, of 6 ft. 8 in. and 10 ft. They are supported on the column heads, and in their turn support either one or two beam connections. The centre line of boundary beams is placed 2½ in. inside the grid line to allow for a double row of beams at the common perimeter of two adjacent bays and also to allow the outer wall cladding of the building to continue uninterruptedly past the boundary beams at each storey height. Where pairs of boundary beams occur they are supported on the same column head. All boundary beams have holes which correspond to the main voids in the rest of the beam structure, to ensure the passage of services.

The primary beams are placed at 3 ft. 4 in. centres across the shorter span of each bay. They consist of two solid pre-cast end units 3 ft. 4 in. long and a varying number of identical, pre-cast, lattice-type intermediate units, 3 ft. 4 in. long and 12¾ in. deep. These units are assembled and prestressed together on the site before erection, to give beams of multiples of 3 ft. 4 in. in span. Jointing is done across the section of the top and bottom booms only: ciment fondu is used and is allowed 24 hours to set. The Freyssinet system of prestressing is used, with two-wire anchorages, either four or eight 0·2-in. diameter wires being used per beam, according to its size and loading.

The secondary beams are made up of units similar to those of the primary beams, but with a projecting web for self-centering on the flange of the primary beams. They are placed at 3 ft. 4 in. centres in the transverse direction, and are assembled unit by unit between the primary beams. After the units are jointed, the prestressing wire is passed along a groove in the outer edge of the lower flange of the beam and through a hole left for it in the primary beam: stressing is carried out on completion of each structural bay. This completes the beam grillage, stressed in both directions.

The system as developed in this prototype does not achieve the spans and loadings required for a large gymnasium, therefore the 50-ft. long gymnasium beams are of slightly different design, the units being stressed together by one ordinary 12-wire Freyssinet cable. The main system has, however, now been further developed to allow for all spans to be erected from the same components, and on future jobs the ordinary roof beams as used elsewhere will be adapted for spans of up to 50 ft., that is 15 modules.

FLOOR AND ROOF SLABS

The floor and roof slabs, which are of solid, unreinforced concrete, are nominally 3 ft. 4 in. square, 2¼ in. thick at the edges, 1¼ in. thick at the middle and slightly domed. They are placed in position within the squares formed by the top flange of the beams. When grouted into position they act with the beam system to form a rigid, monolithic horizontal slab. The floor slab is covered with a 1¼-in. screed; the roof covering, over the monolithic slab, consists of a 3-in. layer of foamed slag concrete, covered with two layers of roofing felt and finished with granite chippings.

A series of roof-light kerbs nominally 3 ft. 4 in. square are substituted for roof slabs where top lighting is required. These kerbs can be used singly or to form strips of roof lighting in multiples of 3 ft. 4 in. in length. A pitched, galvanised steel roof-light frame with a 12-in. vertical upstand and ventilating light on one side is used in conjunction with these kerbs.

In this building the staircase wells were, as an expedient, cast *in situ*. A pre-cast system of construction has, however, now been satisfactorily developed. The staircase stringers are pre-cast and prestressed in the factory by the Freyssinet method. Standard, reinforced-concrete treads, which allow adjustment for different floor-to-floor heights, are placed in position after the erection of the stringers. These treads also form the landings.

CLADDING AND FINISHES

External walling is of cavity construction, consisting of an internal skin of 3-in. pre-cast panels of Bellrock with a honeycomb finish, and an external skin of pre-cast concrete cladding panels; a 1-in. cavity is provided between the two skins. These are shown in Figs. 3 and 4.

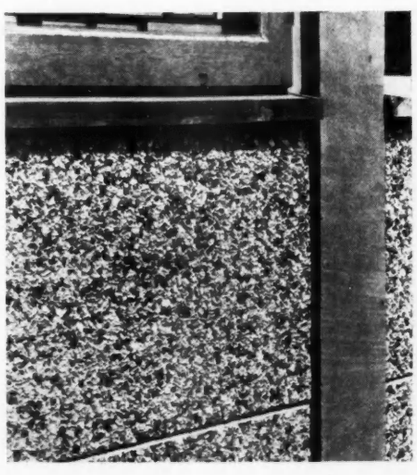

Fig. 4 Three types of external-surface finish have been used including this, which is an exposed aggregate of calcined flint and shingle.

The concrete panels are 1½ in. thick with 3-in. horizontal ribs and edges. They are 6 ft. 8 in. or 10 ft. long, spanning from column to columns, and generally 1 ft. 8 in. deep. Panels 10 in. high are also used so that there is a range of window-sill heights in 10 in. increments. No special lengths are used at internal and external corners, and all handling in erection is from inside the building. There is a component 5 in. in height for use at upstands which require flashing.

Three different types of exposed aggregate finish are used, vibrated into the surfaces of the panels: Derbyshire spar and white cement to produce a white slab; calcined flint mixed with a proportion of shingle to produce a light brownish colour; and black granite in ciment fondu.

The panels fit into the grooves of the columns and are fixed by means of reinforced-concrete pins. Holes in the end ribs of the panels correspond with holes at 10-in. centres in the column; both sets of holes are lined with grout and a tapered pre-cast concrete pin is driven through both, forming a rigid fixing. The D.S.I.R. test for watertightness was carried out on three sections of walling at the school, each section being subjected to heavy jets of water continuously for six hours, and the results have shown the cladding to be waterproof.

The eaves units provide a projection of 12 in. over the face of the external wall and a 4½-in. fascia. The units provide for all corner and abutment conditions and are nominally 3 ft. 4 in. in length. They are bedded on to the roof slab and are held down with bolted galvanised steel stirrups which pass under the end units of beams. All rainwater drainage is external.

A range of timber windows, with hardwood opening lights and sills, and softwood frames, has been designed to fit the structural system. They are erected from within the building in the same way as the cladding panels and the same fixing holes are used in the columns.

Ceiling construction is based on the use of asbestos board bearer strips suspended from the undersides of beams by adjustable clips and placed at 3 ft. 4 in. centres in both directions. This repeats the pattern of the beam grillage, and leaves empty squares into which panels of the various materials which provide sound absorption, fire resistance and the other physical standards necessary, can be fixed.

TESTING OF UNITS

A system of ultra-sonic testing has been evolved for the pre-cast structural units and 60 per cent. of all units manufactured have been tested by this means. The early tests were carried out with the co-operation of the Cement and Concrete Association and the Road Research Laboratory who lent the apparatus initially used. Subsequently the whole of the testing was taken over by Mono Concrete Limited, who were responsible for the casting. A system of relating pulse volocity to compressive strength has been evolved, and a basic figure established which is regarded as a minimum for immediate "passing" of the units. If the minimum is not reached further mechanical testing is applied.

Five tests have shown that the structure gives well over half-an-hour fire resistance without having recourse to special cladding materials.

The heating of the buildings offers certain problems peculiar to schools and similar institutions, in that the premises are only occupied for comparatively short periods. The system chosen makes use of Weatherfoil units, drawing heat initially from a coal-fired boiler. Hot water from the boiler is circulated round the buildings and in each room is a thermostatically-controlled radiator unit. A fan, operated by the thermostat, draws air from the room into the unit over one set of radiator pipes and returns it over another set. This has proved economical in operation as the response is quick and load is only applied to the boiler during periods of actual need.

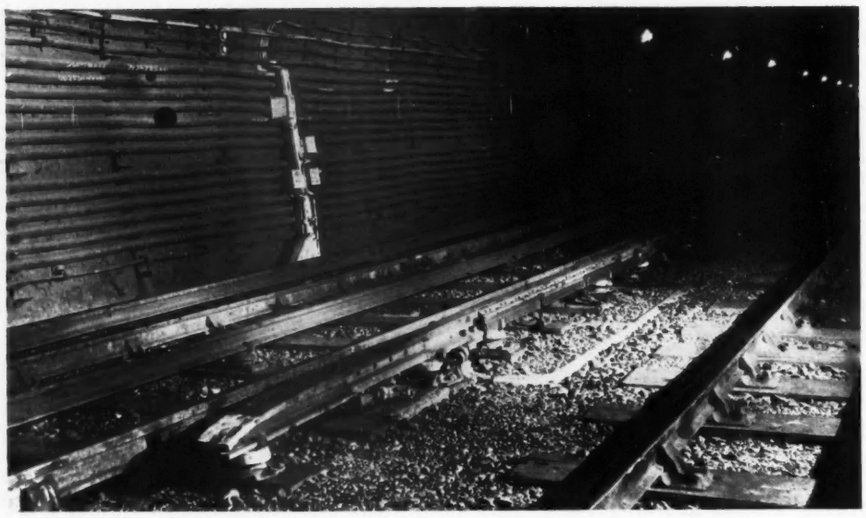

Fig. 1 Length of dummy conductor rail containing detectors for the instantaneous measurement of the speed of London Underground trains.

INSTANTANEOUS MEASUREMENT OF SPEED

NEW APPARATUS FOR LONDON UNDERGROUND TRAINS

Apparatus for the instantaneous detection of train speeds on the London Transport system has been designed by Mr. R. Dell, the signal engineer, and has been brought into use at Victoria on the District line. It will also be installed shortly between Gloucester Road and Mansion House.

As shown in Fig. 1, the detector consists of a length of conductor rail with a stainless steel surface which is laid alongside the track. Below this rail are 12 permanent magnets and coils spaced 9 in. apart, of the form shown in Fig. 2.

When a train passes over the rail the flux from these permanent magnets is attracted to the shoes on the train, thus varying the excitation in the coils and generating a weak alternating current in them. The frequency of this current is proportional to the speed of the train and is therefore a measure of it. The current thus generated is amplified in a Westinghouse amplifier and is fed into a relay, which has been designed to respond only to frequencies below a certain value. It is only when this relay operates, that is when the speed of the train does not exceed a pre-determined limit, that the signal ahead will clear. The detector operates whenever a shoe passes over it, and there is no need for the driver to estimate his speed very accurately at one critical point on the track. In fact, if the speed is excessive as the front shoe passes over the detector the signal will still clear if a reduction to the correct value has taken place by the time the rear shoe passes over the detector.

Speed controlled signalling has been used by London Transport since 1948 to overcome the progressive delays which occur when the first train of a series is abnormally detained at a station. For this purpose a length of track of such length that a train will take about 4½ seconds to pass over it at 25 m.p.h. is employed. A train passing into this timing section operates a relay which is set so that it closes a contact after 4½ seconds. If the speed is less than 25 m.p.h. it will therefore operate before the train has reached the end of the section and the signal will be cleared, so that no delay will occur. An intermediate signal which is next approached is controlled in the same way, but only clears when the speed is lower than say 20 m.p.h., so that the preceding train can be safely approached without loss of running time.

This system is installed between Green Park and Kings Cross and at Liverpool Street. But although the running of the trains has been improved, it has the disadvantage of only measuring the average speed over the timed section, so that the maximum control is not obtained. In the case of a train slowing down rapidly the average speed may be substantially higher than the speed at the end of the section. Since it is the latter speed that is important, it needs skill to regulate the train speed exactly over the timing section. This drawback has, it is claimed, been overcome in the new system.

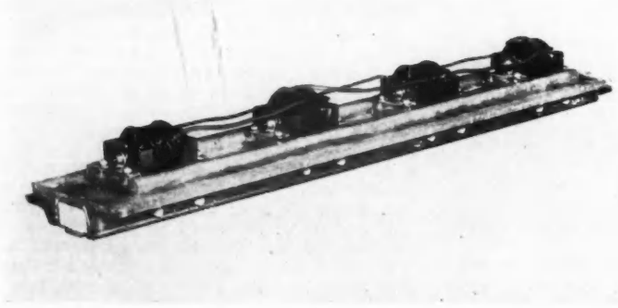

Fig. 2. The detector with cover removed, showing four of the permanent magnets.

SELLING TO WESTERN EUROPE

A Guide to Markets

A down-to-earth and useful pamphlet, called "Selling to Western Europe," has been issued by the Credit Insurance Association Limited, Staple Hall, Stone House-court, London, E.C.3. In addition to a survey of the statistical position of this country's export trade to Western Europe, the pamphlet relates the prospects for British exporters to the economic policy of Western European countries and points out some interesting differences as between different markets.

Member countries of the Organisation for European Economic Co-operation, together with Spain, are discussed and the general point is made that Western Europe is now in an expansionist, optimistic mood. The trend is towards liberalisation of trade because all are highly industrialised countries which cannot afford to cut off their noses to spite their faces by resorting to exorbitant tariffs to protect infant industries. Most of the countries are using imports as a means of countering internal inflation, which is these days a chronic problem but which does have the advantage, so far as other countries are concerned, of encouraging international trade provided balance-of-payments problems do not become so acute that import restrictions have to be introduced. Countries are divided into three groups—those which are an immediate good prospect for increased exports (such as Western Germany and France); those which offer steady but unexciting long-term prospects (such as Sweden and Switzerland); and those which are having acute balance-of-payment difficulties at the moment and are therefore temporarily less attractive prospects (like Norway and Denmark). The pamphlet is up-to-date and takes account of the interesting change of emphasis in the industrial development of Italy which was commented upon in our Weekly Survey two weeks ago.

Two sections of particular interest are those on "The Possibilities in Individual Markets" and "The European Point of View." Here the potentialities of each market are briefly discussed in terms of categories of goods (among which engineering products of all kinds play an important part) and some interesting comments are made upon the Continental attitude and assessment of British industries' efforts to sell its goods on the other side of the Channel.

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A NEW INFRA-RED OVEN

The new standard infra-red oven made by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester 17, is designed for the heat processing of small articles and materials, in batch production. It is suitable for paint stoving, drying of lacquer, moisture drying from chemicals and foodstuffs, etc., curing and softening plastics, and the drying of adhesives.

The oven consists of a floor-mounted sheet-steel casing, housing infra-red tubular sheathed heating elements in trough-shaped anodised-aluminium reflectors in the top of the oven, which heat the materials in the oven by direct radiation. To conserve any stray radiant heat, the sides and floor of the oven are also lined with anodised aluminium sheet. A wire-mesh tray is provided for use in the oven at various heights. All aluminium surfaces are anodised by the Brytal "C" process for heat reflection and also as protection against atmospheric corrosion. The drop-down door is counter-weighted to remain in an open or closed position.

Control equipment is housed in the base of the oven and consists of a switch-fuse unit, energy regulator, contactor and an indicator light. The oven is ventilated round the sides of the top cover into the surrounding atmosphere, but for processes where fumes are given off a suitable flanged outlet can be fitted to take ducting. The approximate overall dimensions are 4 ft. 10 in. high, by 2 ft. 6 in. wide and deep. The full load is 4 kW.

COPYING LATHE WITH CONSTANT CUTTING SPEED

A new design of copying lathe in which the tool is hydraulically-actuated and the drive is steplessly variable, so that a constant cutting speed is maintained irrespective of changes in the diameter of the work, was shown at the recent Swiss Industries Fair by the makers, Edouard Dubied & Cie. S.A., of Neuchatel, Switzerland. The general appearance of the machine can be seen from Fig. 1. It resembles the earlier machine of the same type number in having the hydraulic feed, but the hydraulic system has been completely redesigned to provide the combination of a constant cutting speed with a constant feed per revolution of the work. The variation of the cutting speed is controlled electrically, according to the position and movement of the tool slide.

The hydraulic system comprises three pumps, two being "delivery" pumps and the third a regulating pump. The first delivery pump provides a constant supply of oil to the regulating pump, which controls the supply to the feed cylinder. It is, perhaps, not so much a pump in the ordinary sense as a flow regulator, being entirely relieved of pressure difference by a hydraulic balance; that is, the pressure at the inlet is the same as at the delivery. Thus it always delivers the correct amount of oil to maintain a constant feed movement, irrespective of the load and of the temperature and viscosity of the oil. The operation of the copying device is the function of the second delivery pump, which is driven by the same motor as the first delivery pump. The hydraulic copying device is diagrammatically illustrated in Fig. 3.

The bed of the lathe is of cast iron, attached by a three-point mounting to the cast-iron pedestal, which forms also the oil reservoir. The top of the bed, with the slideways, is steeply inclined to the rear of the machine, which makes the bed casting deeper and therefore stiffer as a girder, and also facilitates the disposal of swarf, which falls directly into a wheeled truck at the rear. The fixed guard cover at the rear is extended to cover the chip truck also. A sliding guard is provided over the headstock and the cutting slide.

The method of achieving the constant cutting speed is by interposing a belt drive on two steplessly adjustable pulleys between the motor and the final drive to the headstock spindle, which is by means of six matched V-belts and a multi-plate clutch. Through a flexible coupling the motor drives the lower of the two shafts carrying the adjustable pulleys; the upper shaft, on which the other adjustable pulley is mounted, also carries the lower of the pair of pulleys for the V-belts. The linkage which simultaneously separates the plates of one pulley while bringing together the plates of the other is actuated by levers connected at one end by a spindle having right-hand and left-hand screw threads. The variable-speed mechanism is shown in Fig. 2.

When starting on a new workpiece the initial speed is selected by the operator to suit the starting diameter of the work and the material to be machined. Thereafter the control is completely automatic, being operated by an electric servo-mechanism coupled to the tool slide; it has a range of regulation of 1 : 7, and can vary the speed of the work over that full range in four seconds.

The headstock is a box casting, in which the spindle, of nickel-chrome steel, heat-treated and ground, is mounted in double-row precision ball bearings. The main bearing has a taper bore for adjustment. The belt pulley is separately mounted and drives the spindle through a multi-plate clutch. The tailstock, which is screw-operated, is adjustable by a tapered and slotted bush and contains a live centre, running in ball bearings. A quick-acting toggle lever is available as an alternative to the screw operation of the tailstock spindle, for use in cases where runs of small repetition work may be experienced.

The distance between centres in the machine described (the 515/400) is 400 mm. (15¾ in.) and the centre height is 120 mm. (4¾ in.), but a larger size is also made, with a distance of 650 mm. (25⅝ in.) and is listed as the 515/650 model. Apart from the difference in the length of bed, the two models are the same in details. Both have a cross-slide travel of 75 mm. (3 in.), a travel of the copying attachment of 50 mm. (2 in.), and a maximum turning diameter of 110 mm. (3⅝ in.). A choice of spindle-speed ranges is available, either from 300 to 2,100 r.p.m. or 570 to 4,000 r.p.m. The corresponding feed ranges are 0 to 0·75 mm. and 0 to 0·40 mm. per revolution. The feed is infinitely adjustable by the hydraulic valve control.

On completion of a traverse, the tool is withdrawn from the work by a predetermined amount and a quick-acting motion returns the carriage to the starting position for the next cut. Various attachments are available for special purposes; for example, a lever clamp for collets, a lunge-cutting device, a drilling attachment, a tool-holder for internal turning, and different types of steady for supporting small spindles and similar light workpieces.

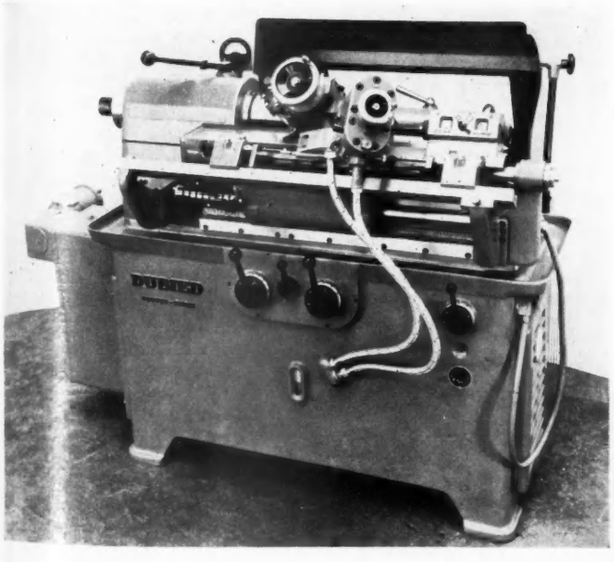

Fig. 1 The tool in this copying lathe is hydraulically actuated and the drive can be varied to maintain a constant cutting speed.

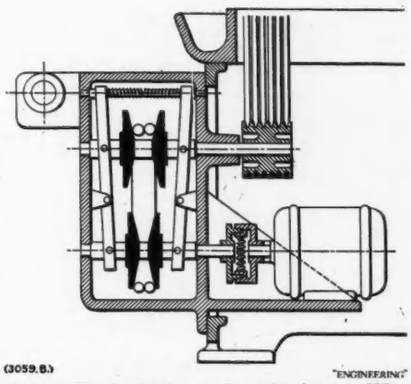

Fig. 2 The variable-speed mechanism. When the lower plates come together the upper plates move apart, and the output speed rises. The speed is continuously variable over a 1 : 7 range.

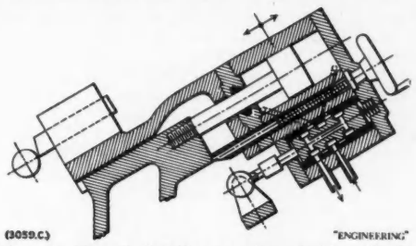

Fig. 3 The hydraulic copying device of the Dubied 515 copying lathe.

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HIGHWAY ENGINEERING

Summer School at Birmingham

To acquaint civil engineers practising in the Midlands with the latest methods of road design, it is intended to hold a special school in highway engineering at the Department of Civil Engineering, University of Birmingham, between Monday, September 12, and Saturday, September 24. The course is being arranged by the Department with the support of the Paviors Company.

The syllabus is to be divided into two parts: Traffic and Safety, and Construction. Under the first heading will be considered such problems as traffic behaviour and control; accidents; financing of road projects, returns and road economics generally. The second half of the syllabus is to be concerned with soil mechanics and geology as is relevant to road construction; soil stabilisation; design of concrete slabs and the use of plant; the properties and choice of surface dressings; and the riding qualities of roads generally.

Further details can be obtained from the Department of Civil Engineering, The University, Edgbaston, Birmingham.

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RADIOACTIVE STATIC ELIMINATOR

A device, known as the Isotron static eliminator, has been designed by Isotope Developments, Limited, Benham Grange, Aldermaston Wharf, near Reading, Berkshire, in conjunction with H.M. Inspectorate of Factories, to remove static electrical charges from sheet materials.

The standard pattern of eliminator consists of a semi-circular bar 12·8 in. long and 2 in. in diameter which is radioactive and is usually mounted at right angles to the line of travel of the sheet and within 0·5 in. of it. In the case of sheets narrower than 1 ft. it can, however, be suspended parallel to the line of travel. In the working position it is protected on all sides by a lead shield except for a slot, which enables the radiation to be directed on to the material. During storage, the radioactive source can be rotated in its holder so that it is covered by a sheet of lead 0·4 in. thick. The weight is 8·5 lb.

ANNEALING BRASS TUBES

ROLLER-HEARTH ELECTRIC FURNACE

In 1950 G.W.B. Furnaces, Limited, Dudley, Worcestershire, supplied a roller-hearth electric furnace to Yorkshire Copper Works, Limited, Leeds, for annealing brass tubes. This installation has now been followed by a second furnace of similar design, but of larger capacity. Both furnaces are shown in the accompanying illustration, the older one of 1 ton per hour capacity being on the left and the newer, which has a capacity of 1½ tons per hour, on the right.

The new furnace is designed to anneal tubes from ¾ in. to 6 in. in diameter in lengths of up to 28 ft., and can deal with up to 1½ tons an hour with an electrical loading of 225 kW and a maximum temperature of 650 deg. C. The usable width of the furnace is 3 ft. 9 in. Heating takes place in three zones, each of which is provided with an independent Electroflo electronic controller. A three-point recording instrument is fitted to the control panel to enable the temperature in each zone to be checked at any time. Operating temperatures range from 325 to 650 deg. C. according to the type of material being heat treated and the heating required. The first two zones, where the initial heating takes place, are each 5 ft. long, and rated at 85 kW. Zone 3 is 10 ft. long with an electrical rating of 55 kW. The zones are fed from the three-phase supply through transformers with tappings for reduced loading in the lower temperature ranges or when the charges are relatively light. The transformers feeding zones 1 and 2 have taps giving 75, 65, 55 and 45 kW, and the tappings on the transformer for zone 3 are 45, 35, 25 and 15 kW. The heating elements, which are of heavy nickel-chromium strip, are in the roof and hearth of the furnace. Those in the roof are suspended from nickel-chromium hooks, while those in the hearth are carried by specially-moulded refractories. A water-jacketed cooling chamber 23 ft. 6 in. long is provided at the exit end of the furnace, and there is an insulated entrance vestibule 1 ft. 6 in. long which is suitable for a gas curtain if required. The roof of the furnace is removable in sections for maintenance purposes. When it is in its working position it rests on a gas-tight sealing trough filled with sand or other suitable material.

VARIABLE-SPEED DRIVE

Tubes are deposited in bundles on a 30-ft. long loading table and spread uniformly over it by hand. This table consists of a set of mild-steel rollers, 3 in. in diameter, flanged at each end, and power driven by means of roller chains and sprockets. They are spaced at 1-ft. centres. On entering the furnace the charge passes to rollers of the same dimensions, but spaced at 6-in. centres to give maximum support to the tubes when they are heated. The rollers throughout the heating zones are of solid-drawn heat-resisting 18/8 chromium-nickel steel, with cast flanges. At the discharge end of the furnace the rollers are again of mild steel, at 1-ft. centres, and form a 30-ft. long unloading table. All the rollers are carried in self-aligning graphite bearings, and are so designed that they can be withdrawn from the side of the furnace when necessary. The drive to the rollers is through a Carter hydraulic infinitely-variable speed gear, which enables the charge travel rate to be adjusted from 6 in. to 60 in. per minute as required.

* * *

CARRIER-CURRENT TELEPHONY ON 300-KV LINE

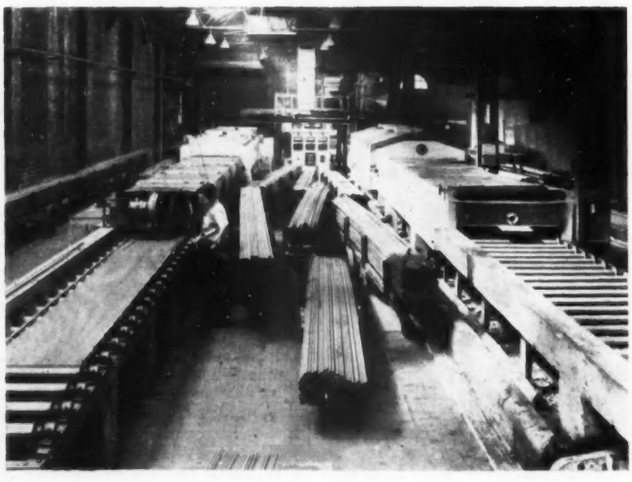
A carrier-current telephone system has been installed by the General Electric Company, Limited, Kingsway, London, W.C.2, to provide communication between the Kemano power station of the Aluminium Company of Canada and the aluminium factory at Kitimat. As already described in ENGINEERING* these two points are separated by 50 miles of mountainous country, which rises to a maximum of 5,300 ft. and power is transmitted between them by two double-circuit overhead lines operating at 300 kV. At the time of their installation there was no telephone connection between the two sites, communication being effected by a very high frequency radio link, which necessitated maintaining a repeater station in difficult terrain.

The power line carrier equipment is of the multi-circuit type, three duplex telephone channels at present providing direct connection between the switchgear control desks at each end. In addition, two channels connect the telephone exchanges at each terminal and permit fully automatic communication between the subscribers on them. There is also a telemetering channel between Kitimat and Kemano to indicate the line voltage received at the latter place, and finally, unidirectional transfer tripping facilities are provided so that if a fault occurs on the overhead lines the appropriate circuit-breaker at Kemano will be opened. Each communication channel is 4 kilocycles wide and includes a speech channel from 300 to 2,700 cycles and a telephone signalling channel of 3,600 cycles.

The equipment is designed to operate on an inter-feeder basis, the signals being transmitted between one phase of one feeder and the corresponding phase of the other. The wave traps are rated for a steady current of 1,600 amperes and the level of the circuits is maintained at their nominal value, even during the severest weather, by a system of automatic gain control. All the common equipment is duplicated and, in the event of a failure, the change-over from normal to stand-by plant is fully automatic.

The equipment is supplied with power from a motor-generator set consisting of an induction motor, which is fed from the local mains and is connected to a single phase alternator through a flywheel. In the event of a failure a direct-current motor on a second set is energised from the station battery and drives another alternator, the flywheel on the main set maintaining the output until the stand-by machine has run up to speed.

* Vol. 177, page 432, 1954.



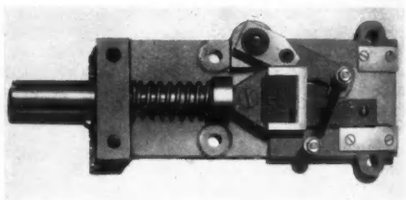
These two G.W.B. electric annealing furnaces installed at Yorkshire Copper Works, Limited, have capacities of 1 ton and 1½ tons of tubes per hour respectively. They are both of the roller-hearth type.

* * *

COIN MECHANISM FOR TURNSTILES

A mechanism has been developed by Sir W. H. Bailey and Company, Limited, Albion Works, Patricroft, Lancashire, which is designed for releasing a turnstile when a coin is inserted. There are only two moving parts. The mechanism is shown in plan in the illustration.

Mounted above the mechanism, and not shown in the illustration, is a selector which can be adjusted to accept only one size of coin. A coin passing through this is guided into the centre slot of the locking mechanism. When in the slot, the edge of the coin engages with a projection on the locking pawl; thus the pawl is lifted when pressure from an arm of the turnstile bears on the projecting plunger. The lifting of the pawl frees the lock and allows the plunger to slide along and free the turnstile arm. During the movement of the plunger, the coin comes opposite a slot in the base-plate and, being then free from the projection on the pawl, falls through under its own weight. When the arm of the turnstile has passed, the plunger returns under the force of the compression spring and is relocked by the pawl. It is claimed that, being automatic, the mechanism allows the passage of traffic through the turnstile to be speeded up as compared to those which need manual operation of the lock.



When a coin has been inserted in the slot of this turnstile release mechanism pressure on the plunger releases the pawl and allows the plunger to move. The coin then falls through a slot in the base-plate.

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RUGELEY A AND AGECROFT B POWER STATIONS

The Central Electricity Authority has received the consent of the Minister of Fuel and Power to the establishment of a new power station at Rugeley, Staffordshire. To be known as the Rugeley A power station, it will have an installed capacity of 240 MW (320,000 h.p.) provided by four 60-MW turbo-generator sets each steamed by a boiler unit having an evaporative capacity of 550,000 lb. an hour.

Consent has also been received for the extension of the Agecroft B power station at Salford by two 120-MW turbo-generator sets and two boiler units each having an evaporative capacity of 860,000 lb. of steam an hour. This plant will increase the installed capacity of the station to 345 MW kilowatts (460,000 h.p.).

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *May 27, page 679; or June 24, page 807. Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

ATOMIC ENERGY FOR INDUSTRIAL USE, EXHIBITION.—Mon., Aug. 8, to Sat., Aug. 20, at Geneva, under the sponsorship of the United Nations Organisation. Some six countries, including the United States, are expected to participate. Apply to the United Kingdom Atomic Energy Authority, 1-13 St. Giles High-street, London, W.C.2. See also ENGINEERING, July 22, page 98, but it should be noted that August 20 is the closing date.

AUTOMOTIVE ENGINEERS, SOCIETY OF.—*West Coast Meeting:* Mon., Aug. 15, to Wed., Aug. 17, at Portland, Oregon. *Aircraft Production Forum and Aircraft Engineering Display:* Tues., Oct. 11, to Sat., Oct. 15, at Los Angeles. *Transportation Meeting:* Mon., Oct. 31, to Wed., Nov. 2, at St. Louis, Miss. *Diesel Engine Meeting:* Wed., Nov. 2, to Fri., Nov. 4. Apply to the Society of Automotive Engineers, 29 West 39th-street, New York, 18.

*"MODEL ENGINEER" EXHIBITION AND EXHIBITION OF INVENTIONS.—See page 136.

MANAGEMENT CONFERENCE.—Fri., Aug. 19, to Sat., Aug. 27, at the University of Connecticut. Sponsored by the University and the Society for the Advancement of Management. Apply to Mr. Joseph Emerzian, University of Connecticut, Storrs, Conn., U.S.A.

MOTOR INDUSTRY SUMMER SCHOOL.—Sat., Aug. 20, to Sat., Aug. 27, at Corpus Christi College, Cambridge. Organised by the Institute of the Motor Industry, 40 Queen's Gate, London, S.W.7. Tel. WEStern 0915. See ENGINEERING, December 10, 1954, page 772.

*SOLAR ECLIPSES AND THE IONOSPHERE, INTERNATIONAL SYMPOSIUM ON.—Mon., Aug. 22, to Wed., Aug. 24, in London. Organised by the Joint Commission on the Ionosphere of the International Council of Scientific Unions (I.C.S.U.). Apply to Dr. W. J. G. Beynon, University College of Swansea, Singleton Park, Swansea. Tel. Swansea 5-7805.

NATIONAL RADIO SHOW.—Wed., Aug. 24, to Sat., Sept. 3, at Earl's Court, London, S.W.5. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

PACIFIC NATIONAL EXHIBITION.—Wed., Aug. 24, to Mon., Sept. 5, at Vancouver. Organiser: Mr. Ben Williams, Exhibition Park, Vancouver, B.C.

CANADIAN NATIONAL EXHIBITION.—Fri., Aug. 26, to Sat., Sept. 10, at Toronto. Information obtainable from Mr. G. H. Ward, 3 Lower Regent-street, London, S.W.1. Tel. WHItehall 2794.

GERMAN RADIO, GRAMOPHONE AND TELEVISION EXHIBITION.—Fri., Aug. 26, to Sun., Sept. 4, at Düsseldorf. Agents: John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

MINNESOTA STATE FAIR.—Sat., Aug. 27, to Mon., Sept. 5. Apply to the British Consulate, First National Bank Building, St. Paul 1, Minn., U.S.A.

MELBOURNE INTERNATIONAL TRADE FAIR AND MODELS EXHIBITION.—Sat., Aug. 27, to Sat., Sept. 10, at Exhibition Buildings, Melbourne. Apply to Rev. L. L. Elliott, 1 Lancaster-grove, London, N.W.3, Tel. PRImrose 7777; or to Miss J. H. Jeffery, 112 Maltravers-road, Ivanhoe, Melbourne.

PRESTRESSING, CONFERENCE ON.—Mon., Aug. 29, to Fri., Sept. 2, at the Royal Tropical Institute, Mauritskade 63, Amsterdam 0, Holland. Organised by the Fédération Internationale de la Précontrainte, Groningsestraat 15, The Hague. See ENGINEERING, December 17, 1954, page 782.

*AMERICAN MATHEMATICAL CONGRESS.—Tues., Aug. 30, to Sat., Sept. 3, at Ann Arbor, Michigan, U.S.A. Organised by the American Mathematical Society, 80 Waterman-street, Providence 6, Rhode Island, U.S.A.

BRITISH ASSOCIATION MEETING.—Wed., Aug. 31, to Wed., Sept. 7, at Bristol. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109. See ENGINEERING, February 11, page 168.

*HYDRAULICS RESEARCH, INTERNATIONAL ASSOCIATION, GENERAL MEETING.—Wed., Aug. 31, to Tues., Sept. 6, at The Hague. Organised by the International Association for Hydraulic Research, Raam 61, Delft, Holland.

*REFRIGERATION, 9TH INTERNATIONAL CONGRESS.—Wed., Aug. 31, to Thurs., Sept. 8, in Paris. Organised by the Institut International du Froid, 177 Boulevard Malesherbes, Paris 17e.

ENGINEERING, MARINE, WELDING AND FOUNDRY TRADES EXHIBITION (20TH).—Thurs., Sept. 1, to Thurs., Sept. 15, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, London, W.C.2. Tel. WHItehall 0568.

PAKISTAN INTERNATIONAL INDUSTRIES FAIR.—Fri., Sept. 2, to Sun., Oct. 2, at Karachi. *Agents:* Auger and Turner Group Ltd., 40 Gerrard-street, London, W.1. Tel.: GERrard 6671.

STRASBOURG EUROPEAN FAIR.—Sat., Sept. 3, to Sun., Sept. 18, at Wacken, Strasbourg, France. *Agent:* R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

LEIPZIG INTERNATIONAL FAIR.—Autumn Fair: Sun., Sept. 4, to Fri., Sept. 9. Apply to Leipzig Fair Agency, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

*HISTORICAL SCIENCES, 10TH INTERNATIONAL CONGRESS.—Sun., Sept. 4, to Sun., Sept. 11, in Rome. Apply to Professor F. Chabod, Congrès International des Sciences Historiques, Université, Rome.

MATHEMATICAL COLLOQUIUM, BRITISH.—Tues., Sept. 6, to Thurs., Sept. 8, at Exeter. Apply to Secretary, 7th British Mathematical Colloquium, University College of the South-West of England, Exeter. Tel. Exeter 4141.

CHICAGO EXHIBITIONS.—Tues., Sept. 6, to Sat., Sept. 17. Metal-Working Machinery and Equipment at the Coliseum; Machine Tools at the International Amphitheatre; and Production Equipment at the Navy Pier. Organisers: Exhibition and Convention Management, Inc., 2689 East Overlook-road, Cleveland 6, Ohio, U.S.A.

GHENT INTERNATIONAL FAIR, INCLUDING PRINTING AND PUBLISHING TRADES EXHIBITION AND QUINQUENNIAL EXHIBITION OF SCIENTIFIC AND INDUSTRIAL LABORATORY EQUIPMENT.—Sat., Sept. 10, to Sun., Sept. 25, at Ghent, Belgium. *Agents:* S. R. Tippett & Co., Ltd., 110 Cannon-street, London, E.C.4. Tel. MANsion House 4500.

*COSMIC RADIATION CONFERENCE.—Sat., Sept. 10, to Thurs., Sept. 15, in Mexico. Organised by the International Congress on Cosmic Radiation (I.U.P.A.P.). Apply to Professor P. Fleury, 3 Boulevard Pasteur, Paris 15e, or to Dr. Henry A. Barton, 57E 55th-street, New York 22.

*WELDING, INTERNATIONAL INSTITUTE, ANNUAL ASSEMBLY.—Sun., Sept. 11, to Sat., Sept. 17, at Zürich. Apply to the Offices of the Institute, 2 Buckingham Palace-gardens, London, S.W.1. Tel. SLOane 9851.

LIBRARIES AND DOCUMENTATION CENTRES CONGRESS.—Sun., Sept. 11, to Sun., Sept. 18, at Brussels. Information obtainable from Aslib, 4 Palace-gate, London, W.8. Tel. WEStern 6321.

INSTRUMENT EXHIBITION AND CONFERENCE (10TH ANNUAL).—Mon., Sept. 12, to Fri., Sept. 16, at the Shrine Exposition Hall, Los Angeles. Sponsored by the American Society of Mechanical Engineers. Organised by the Instrument Society of America, 3443 South Hill-street, Los Angeles 7, California, U.S.A.

*INFORMATION THEORY, 3RD SYMPOSIUM.—Mon., Sept. 12, to Sat., Sept. 17, in London. Apply Dr. E. Cherry, M.Sc., Imperial College of Science and Technology, Prince Consort-road, London, S.W.7. Tel. KENsington 4861.

GAS SALES AND SERVICE CONFERENCE (FOURTH).—Mon., Sept. 12, to Wed., Sept. 14., at the Heads of Ayr Holiday Camp, Ayr, Scotland. Organised by the Gas Council, 1 Grosvenor-place, London, S.W.1. Tel. SLOane 4554. (Alteration of dates).

ELECTROMAGNETICALLY-ENRICHED ISOTOPES (CONFERENCE).—Tues., Sept. 13, to Fri., Sept. 16, at the Atomic Energy Research Establishment, Harwell, Berks. Tel. Abingdon 620. See ENGINEERING, March 11, page 321.

*CAVITATION IN HYDRODYNAMICS, SYMPOSIUM.—Wed., Sept. 14, to Sat. Sept. 17, at Teddington. Apply to the Director, National Physical Laboratory, Teddington, Middlesex. Tel. Molesey 1380.

COMPUTING MACHINERY CONGRESS.—Wed., Sept. 14, to Fri., Sept. 16, at the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, U.S.A. Apply to Association for Computing Machinery, Building 13–2, Camden 2, New Jersey, U.S.A.

WELLINGTON DIAMOND JUBILEE EXHIBITION.—Thurs., Sept. 15, to Sat., Oct. 1. Organised by the Wellington Manufacturers Association (G.P.O. Box 844), Manufacturers' Chambers, Corner of Willis and Ghuznee-streets, Wellington C.2, New Zealand.

*ELECTRICAL POWER, INTERNATIONAL UNION OF PRODUCERS AND DISTRIBUTORS OF.—Mon., Sept. 19, to Sun., Sept. 25, meeting, in London. Apply to the secretary of the Union, 12 Place des Etats-Unis, Paris 16e.

ELECTRICAL ENERGY CONGRESS.—Mon., Sept. 19, to Fri., Sept. 23, Church House, Dean's Yard, London, S.W.1. Tenth congress of the International Union of Producers and Distributors of Electricity (UNIPEDE). Apply to the Public Relations Officer, British Electricity Authority, Winsley-street, London, W.1, Tel. MUSeum 4040; or to the Information Department, North of Scotland Hydro-Electric Board, 16 Rothesay-terrace, Edinburgh, 3. Tel. Edinburgh Central 1361. See ENGINEERING, January 21, page 71.

ROYAL AGRICULTURAL SHOW.—Thurs., Sept. 22, to Sat., Oct. 1, at Melbourne. Organised by the Royal Agricultural Society of Victoria, Melbourne.

*MINERAL RESOURCES STRATEGY, SYMPOSIUM.—Thurs., Sept. 22, in London. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. Tel. NATional 0621. See ENGINEERING, July 22, page 128.

*ASLIB ANNUAL CONFERENCE.—Fri., Sept. 23, to Mon., Sept. 26, at Blackpool. Apply to offices of Aslib, 4 Palace-gate, London, W.8. Tel. WEStern 6321.

*PETROLEUM AND MECHANICAL ENGINEERING CONFERENCE.—Sun., Sept. 25, to Wed., Sept. 28, at New Orleans. Organised by the American Society of Mechanical Engineers, 29 West 39th-street, New York 18.

IRON AND STEEL ENGINEERS, ASSOCIATION OF (AMERICAN).—*Annual Convention:* Mon., Sept. 26, to Thurs., Sept. 29, at Chicago. Apply to Association of Iron and Steel Engineers, Empire Building, Pittsburg 22, Pa., U.S.A.

*ANALOGUE COMPUTING, INTERNATIONAL CONFERENCE.—Tues., Sept. 27, to Sat., Oct. 1, at Brussels. Apply to Mr. P. Germain, Institut de Physique Appliquée, Université Libre de Bruxelles, 50 Avenue Franklin Roosevelt, Brussels.

NATIONAL SMOKE ABATEMENT SOCIETY'S ANNUAL CONFERENCE.—Wed., Sept. 28, to Fri., Sept. 30, at Bournemouth. Apply to Society's offices: Palace Chambers, Bridge-street, London, S.W.1. Tel. TRAfalgar 6836.

ROYAL AGRICULTURAL SHOW.—Sat., Oct. 1, to Thurs., Oct. 6, at Claremont, Western Australia. Organised by the Royal Agricultural Society of Western Australia, 9 Howard-street, Perth.

*AUTOMATIC CONTROL IN THE PROCESS INDUSTRIES, CONFERENCE ON.—See page 133.

METALS EXPOSITION (37TH NATIONAL).—Mon., Oct. 17, to Fri., Oct. 21, at Detroit. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

CANADIAN INDUSTRIAL TOOL AND EQUIPMENT SHOW.—Mon., Oct. 24, to Fri., Oct. 28, at the Show Mart Building, Montreal. Inquiries to the show offices: 4585 Sherbrooke-street W., Montreal.

ROYAL AGRICULTURAL WINTER FAIR.—Fri., Nov. 11, to Sat., Nov. 19, at Toronto. Organised by the Royal Winter Fair Authorities, Royal Coliseum, Exhibition Park, Toronto 2B, Canada.

BUILDING EXHIBITION (26TH).—Wed., Nov. 16, to Wed., Nov. 30, at Olympia, London, W.14. Apply to the Building Trades Exhibition, 4 Vernon-place, London, W.C.1. Tel. CHAncery 2223.

DOCUMENTATION OF APPLIED CHEMISTRY CONGRESS.—Tues., Nov. 22, to Fri., Nov. 25, at the Institut Français du Royaume Uni, Queensberry-place, London, S.W.7. Apply to the International Congress on Documentation of Applied Chemistry, 56 Victoria-street, London, S.W.1. Tel. VICtoria 5974.

METAL-PHASE TRANSFORMATIONS, SYMPOSIUM.—In November. Apply to the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 6233. See ENGINEERING, December 3, 1954, page 723.

Labour Notes

PATTERNMAKING

Complaints from members, branches and district committees have been received by the United Patternmakers' Association from time to time about the inroads which are being made into the patternmakers' trade by tool fitters and other operatives, owing to modern industrial developments.

Shell moulding is another direction in the movement towards increased productivity which concerns the union, and which has been the subject of a number of negotiations at local levels. The introduction of the completely mechanical foundry in the United States, where castings, untouched by hand, come off the production line with but little supervision, is a further aspect of the matter meriting serious consideration.

Although the production of these automatic foundries may give cause for some concern, Mr. W. B. Beard, O.B.E., the union's general secretary, states in his annual report for 1954, that this innovation must result in more accurate and varied patternmaking. Further developments, Mr. Beard considers, are bound to come in cases where mass-production methods can be employed and such products as cylinder blocks are likely to be made by these means within the coming twelve months.

IMPORTANCE OF APPRENTICESHIPS

Craftsmen such as the highly-skilled patternmaker or tool fitter, Mr. Beard continues, will doubtless continue to find their place in the scheme of things. That is another reason why the selection and training of apprentices is becoming so important and why the union should have some control over these matters.

At the same time, he states, it is his opinion that a rigid fixed ratio of apprentices to journeymen is wrong, mainly for the reason that it is applied generally, without regard to local circumstances. It is, indeed, possible to imagine conditions under which the union's present ratio would be much too large. The main task, therefore, must be to secure joint consultations and agreement on these problems.

It should not be the policy of the union to prevent boys from entering the trade. Emphasis should rather be placed on making sure that the right kind of boy was attracted. The question of the ratio of apprentices to journeymen was one which should be considered from the point of view of obtaining enough qualified men to do the work available, but without the fear of causing unemployment, a decline in standards of workmanship, or a lowering of wages. If such action were not taken, there would be a risk " in this developing world of new ideas and materials," of a breakdown in the patternmaking trade.

It should not be overlooked that, in the United States, where an apprenticeship training is compulsory, and where the selection and supervision of boys is in the hands of a body composed of representatives of the employers, trade union and education authority, different types of patternmaking were paid at different rates.

Patternmakers in foundries were paid less than men employed in the average factory. Men engaged in plastics work were organised in a separate category and there was an agreement whereby the ordinary patternmaker could work in plastics but the man trained only in plastics could not take up other work.

TECHNICAL APPOINTMENTS

Among the most interesting sections of the annual report of the Ministry of Labour and National Service for 1954, is that on the working of the Ministry's appointments service, which is recorded as having filled over 15,300 vacancies during the year. It is stated that 240 of these vacancies were in respect of appointments overseas.

Throughout the twelve months, the Ministry's technical personnel committee continued to keep in touch with the demand for engineers and scientists. About 1,800 of the total number of vacancies filled in 1954 passed through the Technical and Scientific Register. In most branches of engineering and science, the demand for qualified employees remained high, attaining a level approximately 25 per cent. in advance of that for the previous year. The demand for mechanical engineers, electrical engineers and physicists was particularly acute.

The Technical Assistance Recruitment Unit of the Register was responsible for filling 78 appointments for scientists and technical experts overseas. In this connection, the arrangements operating in previous years were strengthened by the setting up of a special overseas appointments committee, with Sir George Gater as chairman, to handle posts of special importance for which outstanding candidates were required.

At the end of 1954, there were nearly 4,000 men and women on the Technical and Scientific Register, of whom about one in four were disengaged.

The Ministry's appointments offices filled about 3,000 vacancies, but there were over 14,000 men and women on their registers at the end of the year and, of these, some 6,000 were unemployed. Opportunities of securing work for the younger candidates were good, but, as far as the older men and women were concerned, efforts to place them in employment continued to be " an uphill effort."

Further comment on the report is given on page 135.

RAILWAY PRODUCTIVITY

The first meeting of the British Railways Productivity Council, set up jointly by British Railways and the industry's trade unions, was held in London on July 20.

The Council had its origin in the prolonged negotiations last year on the wage claims in the industry. When, eventually, certain increases were conceded, the unions agreed to co-operate with the British Transport Commission in improving railway efficiency and effecting economies.

It is understood that the new body has not met previously because, for most of the period since its establishment, the two sides of the industry have been at variance on the subject of further wage demands.

According to an announcement issued after the meeting, a sub-committee has been formed, comprising four representatives from the Commission and one from each of the four railway unions, to review the existing arrangements for joint consultations on British Railways. A preliminary meeting was expected to take place this week.

Nine members of the Council have been appointed by the Commission, one of whom, Mr. J. C. L. Train, will serve as the organisation's chairman. Each of the four railway unions, the Associated Society of Locomotive Engineers and Firemen, the National Union of Railwaymen, the Transport Salaried Staffs' Association, and the Confederation of Shipbuilding and Engineering Unions, has appointed two members. In the case of the A.S.L.E.F., the representatives are the President of the union, Mr. N. A. Pinches, and its assistant general secretary, Mr. A. Hallworth. The other unions have chosen their general secretaries as one of their representatives.

RISE IN RETAIL PRICES

A substantial advance in the level of the interim index of retail prices occurred during the four-weekly period ended June 14, when, for the fourth time since the introduction of the index, an increase of three points in one month was recorded.

The Ministry of Labour announcement, issued on Wednesday of last week, stated that a figure of 150 had been recorded for mid-June, so that the average level of retail prices at that date was 50 per cent. above those in force eight years ago.

Increases in the prices of vegetables are held by the Ministry to be the principal cause of the rise in the index figure. In many areas, stocks of old potatoes have become exhausted at an earlier date than usual, and their place has had to be taken by new potatoes at higher cost. There have also been advances in the average prices of some other foodstuffs, such as eggs and cooking apples, and in the cost of road and railway passenger fares.

COAL PRICES PROTEST

Sir Norman Kipping, Director-General of the Federation of British Industries, in a letter to the National Coal Board, sent early last week, estimated that the proportion of the latest increase in coal prices ultimately falling on industry would amount to about £40 million a year.

He informed the Board that the F.B.I. protested very strongly at the increase and requested that there should be an entirely new scrutiny of the whole basis on which it had been calculated. Introduced suddenly, as the increase was, it would not only handicap competitive power in the heavy-fuel using and power-using industries, but would entail substantial losses on existing contracts. No competitive industry could possibly subject its customers to an increase of 18 per cent., almost without notice.

In his reply, Sir Hubert Houldsworth, the chairman of the Board, listed four main reasons why the cost of producing coal had risen and was continuing to rise. These were the effect on the coal industry of advances in wages and prices throughout the nation's general economy; the heavy losses already incurred on the importation of coal from overseas for the benefit of the country as a whole, and, in particular, to maintain industrial productivity; higher interest and depreciation charges on the Board's growing capital-development programme; and increased expenditure on measures designed to promote safety and health in the mines.

Extensive capital expenditure was necessary all the time, in the effort to replace the exhausted coal-producing capacity of the mines. The results of reconstruction were, inevitably, slow to appear. The Board was endeavouring to cover 40 years of normal reconstruction work in only ten years and, indeed, to provide within a space of ten to 15 years an 80 per cent. new industry.

AN IMPERSONAL MONOPOLY

Many aspects of the subject were dealt with in the parliamentary debate on the coal industry in the House of Commons on Wednesday of last week.

Mr. F. W. Farey-Jones, the Conservative Member for Watford, made the point that Parliament in setting up the National Coal Board had created the largest monopoly in the Commonwealth. A monopoly, moreover, which was completely impersonal in its effects on the miners and which was attempting far too much that it should not. The functions of the Board should be telescoped into the production of coal and the humanising of the industry. The gas and electricity industries should be given more freedom.

In his opening of the debate, Mr. Geoffrey Lloyd, the Minister of Fuel and Power, stated that the Government had long desired to re-establish this country in its traditional role as an exporter of coal. The target for exports had been maintained at about 13 million tons a year, but, with the agreement of the Board and the National Union of Mineworkers, the target for 1954 had been increased by five million tons, in view of the anticipated rise in productivity.

From the time of that agreement, coal production had declined. The Government had reluctantly decided that there must be a sharp reduction in exports in 1956, and this would bring about a corresponding decline in imports. Only oil could provide prompt assistance to the coal industry. Increased use of oil would begin later this year. It would rise sharply during 1957, and, by 1960, the equivalent of over four million tons of coal would be used for steam raising on a large scale. From 1960, arrangements for using atomic energy would begin to have their effect.